MONITORING, AUDITING AND ADMINISTRATION COSTS FOR REVISIONS TO REGULATION 308

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MONITORING, AUDITING AND ADMINISTRATION COSTS FOR REVISIONS TO REGULATION 308

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EXECUTIVE SUMMARY

1.0 Introduction

The Ministry of the Environment (MOE) has proposed that Regulation 308 (Reg. 308) be revised so that the existing point of impingement standards are replaced with new ambient air standards and technology-based emission limits. The proposed revisions are expected to result in greater control of emissions and increased control costs.

The objective of this study is to estimate the additional monitoring, auditing and administration costs required to ensure compliance with the proposed revisions for each major industrial sector, for waste disposal companies, for municipalities, and for the MOE.

A number of tasks were performed in the preparation of the estimates of additional monitoring, auditing and administration costs. Background information concerning proposed changes to Reg. 308 and the contaminants and scenarios considered in the subsequent cost estimates are discussed in Chapter 2. The technology of continuous emission monitoring systems (CEMS) for gaseous process effluents, the sampling and analytical methodologies for stack sampling, and for ambient air quality monitoring are described in Chapters 3, 4 and 5 respectively. These monitoring technologies are later applied to various processes in industry so that the cost estimates of monitoring emissions could be determined.

Specific sectors and processes within broader Standard Industrial Classification (SIC) categories are examined in Chapter 6. Existing emissions, and employment and plant data set out in the

Abatement Study are also identified. Using information discussed in Chapters 2 to 6, Chapter 7 provides estimates, by SIC categories, of the capital and annual operating costs to industry for monitoring alternative abatement scenarios. Chapter 8 provides estimates of costs associated with the auditing and administration of the proposed revisions to Reg. 308. The results of the study are summarized in Chapter 9.

2.0 Background Information and Assumptions

Proposed Revisions

The most significant change in Reg. 308 is the new approach of controlling air emissions at source before they are released into the atmosphere.

A proposed three level control system has been followed in this study. Level 1 has the strictest controls and would deal with high hazard contaminants. Level 1 corresponds to the emission control strategy developed in the U.S. known as LAER or Lowest Achievable Emission Rate. Level 2 has moderately strict controls for medium hazard contaminants which would require reduction by the Best Available Control Technology which is Economically Achievable (BACT-EA). Level 3 controls are the least stringent and would apply to low hazard contaminants which can be controlled by technology generally demonstrated as acceptable. Level 3 corresponds to the control strategy referred to as New Source Performance Standards, or NSPS.

Contaminants Considered

The following contaminant groups have been considered:

- volatile organic compounds

    - chlorinated
    - aliphatics
    - aromatics
    - esters, ethers, aldehydes, ketones
    - mercaptans
- particulates associated
    - organic
    - metals
- other particulate matter
- semi volatile organics
- pesticides
- corrosives
    - acids
    - bases
- others

Assumptions

One hundred per cent compliance with existing Reg. 308 and the proposed revisions to Reg. 308 has been assumed for the purposes of this study. It is recognized that this level of compliance will only be approached with a greatly enhanced monitoring and enforcement effort by MOE.

3.0 Continuous Monitoring

Definition

A continuous emission monitoring system (CEMS) is a device that will give a series of on-line measurements of the concentration of specific components that may be contained in a gaseous effluent.

At present CEMs are not in widespread use in North America. The

U.S. EPA has drafted a number of regulations covering these "systems", but the number of fully regulated and documented systems in operation is quite small, and of recent origin.

Two types of CEMs have been developed in the U.S., namely compliance and non-compliance. In general the compliance systems must satisfy a much higher standard of reliability and accuracy than the non-compliance systems, and hence compliance systems are more expensive.

4.0 Stack Sampling

Sampling and Analytical Methodologies

To measure the emission of air pollutants from a stationary source there are essentially five systems.

- Method 5 Sampling Train
- Modified Method 5 Sampling Train
- Volatile Organic Sampling Train
- Grab Sampling Train
- Continuous Analyzer Sampling Train

These systems are summarized in Table S.1

5.0 Ambient Air Quality Monitoring

Developing sampling and analytical methods for each of the contaminants for which an ambient air quality criterion is proposed is a difficult task.

Almost every air monitoring program deals with different compounds. As a result, a variety of techniques is required to cover the prescribed range of contaminants.

Environment Canada has identified eight standard reference methods, and MOE has developed a number of monitoring protocols for conventional pollutants.

As MOE is now proposing to regulate more than 200 organic and inorganic compounds, the methods employed for conventional pollutants may require modifications.

There are three generic sets of methodologies to sample air toxics. One involves sampling compounds that are predominantly in a gaseous phase at ambient temperature and pressure. A second set of methods applies to sampling non-volatile and polar compounds that exist partially or exclusively on the surface of suspended particulate matter. The third series of techniques is known as field screening techniques. These are techniques that can be accomplished in the field with relatively inexpensive instrumentation.

6.0 Industry Sectors

The sectors evaluated in this study were selected by the MOE and are listed below.

- open pit mining
- food industry
- pulp and paper and allied products
- iron and steel industry
- foundries
- non ferrous smelters and refineries
- automotive industry
- inorganic chemical manufacturing
- petroleum refineries
- asphalt paving
- petrochemical products manufacturing

- electrical power generation
- waste disposal facilities
- municipal incinerators

These are further separated into four digit Standard Industrial Classification (SIC) categories and individual processes. Based on discussions with the MOE, availability of data, and on combining of similar categories, a total of 43 SIC categories and 136 processes were addressed in this report.

7.0 Alternative Abatement Scenarios, Industry Monitoring Costs

Five abatement scenarios are considered. They include Scenario A which requires that control Level 2 (BACT-EA) is applied to most contaminant groups, a more stringent Scenario B under which control Level 1 (LAER) is applied to most contaminant groups and Scenario C for which a less stringent level of control, Level 3 (NSPS), is applied to most contaminant groups. In addition, two other scenarios are examined: a two-tiered Scenario D, and a phased-in Scenario E which is identical to Scenario A, but implemented more slowly. The contaminant group and degree of control by scenario are shown in Table 2.2.

The estimated capital and operating costs by industrial sector have been prepared for each of the five scenarios. Scenarios A, B and D all have identical capital costs of $479 million. Of these three scenarios, B has the highest operating cost estimated at $258 million, while both Scenarios A and D are $19 million lower at $239 million.

Scenario C has the lowest capital cost at $435 million and the lowest operating cost at $165 million.

Scenario E differs from the other scenarios in that it has a slower rate of implementation. In the first 15 years, capital costs would amount to $324 million, and annual operating costs, $161 million. At the end of 20 years, a further capital expenditure of $155 million would be incurred, and annual operating costs would amount to $233 million.

8.0 Costs Associated with the Auditing and Administration of the Proposed Revisions to Regulation 308

At present MOE annually spends approximately $17.7 million in administering Reg. 308. This is based on a yearly volume of 1200 Certificates of Approval.

Having a yearly volume of 1200 Certificates of Approval, the estimated annual costs to MOE resulting from the implementation of the proposed revisions to Reg. 308 are $26.8 million.

There are 3,669 firms in our inventory. Providing a Certificate of Approval to all these firms will entail a cost to MOE of $81.8 million. It is not anticipated that all these firms would be granted a certificate in any one year; rather, the cost for these firms would be spent over several years.

Table S.1

STACK SAMPLING AND ANALYTICAL METHODOLOGIES

System	Primary Use	Analytical Methodologies
Method 5 Sampling Train	. to determine the concentration of particulate matter and the emission rate of a gas stream from a stationary source . standard reference methodologies also for asbestos, silica, metals, various inorganics	. for metals such as arsenic, beryllium, lead: Inductively Coupled Argon Plasma Spectroscopy (ICAP); Atomc Absorption Spectroscopy (AAS) . for mercury: Cold Vapour Atomic Absorption Spectroscopy (CVAAS) . for asbestos fibers: principle of optical-phase-contrast microscopy . for silica: principle of x-ray diffraction . for many inorganics: ion chromatography, specific ion electrode, colourmetry, titration
Modified Method 5 Sampling Train (MM5)	. to collect organic compounds with boiling points greater than 100°C . adapted from Method 5; inclusion of a sorbent module of porous polymeric resin to adsorb semi-volatile organic species . standard reference methodologies for organics such as PAHs, CDDs, CDFs, PCBs, chlorobenzenes, and chlorophenols	. based on gas chromatographic (GS) principles and sometimes in combination with mass spectrophotometry (GS/MS)
Volatile Organic Sampling Train (VOST)	. to collect vapour phase organic compounds with boiling points in range of 30°-100°C . may sometimes be used to measure organics with boiling points between 100-140°C . organic species suited to VOST sampling: acrylonitrile, benzene, carbon tetrachloride, chloroform, ethylene oxide, toluene	. same as for MM5
Grab Sampling Train	. for measuring common gaseous pollutants such as SO_2, NO_x, organics, vinyl chloride . not as accurate as other methods	. gas chromatography (GC)
Continuous Analyser Sampling Train	. for measuring contaminants emitted from stationary sources . for pollutants such as total hydrocarbons, SO_2, total reduced sulfur, NO_x	

1.0 INTRODUCTION

The Ministry of the Environment (MOE) has proposed that Regulation 308 (Reg. 308) be revised so that the existing point of impingement standards are replaced with new ambient air standards and technology based emission limits. The proposed revisions are expected to result in greater control of emissions and increased control costs.

The objective of this study is to estimate the additional costs required for monitoring, auditing and administration to ensure compliance with the proposed revisions for each major industrial sector, for waste disposal companies, for municipalities, and for the MOE.

Scope of Work

A number of tasks were performed in the preparation of the estimates of additional monitoring, auditing and administration costs. In brief, they included:

- Identification of a comprehensive set of air pollution monitoring procedures and technologies and the contaminants to which they are applicable.
- Preparation of a reasonable range of capital and operating cost estimates for the different procedures and technologies, based on experience, literature and industry sources.
- In conjunction with Ministry staff, and for the purpose of this study, identification of Lowest Achieveable Emission Rate (LAER), Best Available Control Technology which is Economically Achievable (BACT-EA) and New Source Performance Standards (NSPS) monitoring requirements and the associated costs of implementation for each industrial sector.

- Selection of a number of representative plants (industrial, waste disposal and municipal) and, in collaboration with the Ministry and industry, estimation of monitoring costs required to ensure LAER, BACT-EA and NSPS compliance.
- Preparation of additional monitoring cost estimates for five implementation scenarios and a planning horizon provided by the MOE.

The results of the work are presented in the following chapters. Background information concerning proposed changes to Reg. 308 and the contaminants and scenarios considered in the subsequent cost estimates are discussed in Chapter 2. The technology of continuous emission monitoring systems (CEMS) for gaseous process effluents, the sampling and analytical methodologies for stack sampling, and for ambient air quality monitoring are described in Chapters 3, 4 and 5 respectively. These monitoring technologies are later applied to various processes in industry so that the cost estimates of monitoring emissions could be determined.

Specific sectors and processes within broader Standard Industrial Classification (SIC) categories are examined in Chapter 6. Existing emissions, and employment and plant data set out in the Abatement Study are also identified. Using information discussed in Chapters 2 to 6, Chapter 7 provides estimates, by SIC categories, of the capital and annual operating costs to industry for monitoring alternative abatement scenarios. Chapter 8 provides estimates of costs associated with the auditing and administration of the proposed revisions to Reg. 308. The results of the study are summarized in Chapter 9.

Relevant references and tables are included at the end of each chapter.

2.0 BACKGROUND INFORMATION AND ASSUMPTIONS

2.1 Proposed Revisions

The most significant change in Reg. 308 is the new approach of controlling air emissions at source before they are released into the atmosphere. These emission limits are to be achieved in whatever way the emitters wish. The new approach is based on controlling emissions at source, as opposed to the existing approach of ensuring concentrations of contaminants off-property are such that harm to others, vegetation or property will not occur.

Contaminants are to be ranked based on their toxicity, persistence, bioaccumulative and transport characteristics (MOE, 1987). The proposed ranking would use a scoring system in which chemicals are evaluated in a number of categories, each representing an important hazard to health or property. Substances with high toxicity would be rated as high hazard contaminants. Emitters releasing these substances would be required to reduce them to the lowest achieveable levels attained by the best removal technology known. Substances rated as medium or low hazard would be subject to controls appropriate to their classification. In order to ensure the prescribed control levels are achieved and maintained, emission monitoring would also be a requirement of the proposed revisions to Reg. 308.

A proposed three level control system has been followed in this study. Level 1 has the strictest controls and would deal with high hazard contaminants. Level 1 corresponds to the emission control strategy developed in the U.S. known as LAER or Lowest Achievable Emission Rate. Level 2 has moderately strict controls for medium hazard contaminants which would require reduction by the Best Available Control Technology which is Economically

Achievable (BACT-EA). Level 3 controls are the least stringent and would apply to low hazard contaminants which can be controlled by technology generally demonstrated as acceptable. Level 3 corresponds to the control strategy referred to as New Source Performance Standards, or NSPS.

Once promulgated, the revisions with both abatement and monitoring requirements will come into effect immediately for all new sources. For the existing sources, all emitters would be phased in within five years.

2.2 Contaminants Considered

In December 1987 the MOE discussion paper on proposed amendments to the Air Pollution General Regulation 308 included a list of proposed ambient air standards for contaminants of concern (MOE, 1987). Based on discussions between the MOE and the study group, a subset of 93 contaminants was selected for consideration in this study. The contaminants were further classified into the following groups.

- volatile organic compounds
  - chlorinated
  - aliphatics
  - aromatics
  - esters, ethers, aldehydes, ketones
  - mercaptans
  - others
- particulates associated
  - organic
  - metals
- other particulate matter
- semi volatile organics

- pesticides
- corrosives
  - acids
  - bases
- others

In assessing a compound's volatility, the following EPA definitions were used (Lewis, 1986):

- volatile organic compounds:
  - compounds having a saturated vapour pressure at 25°C above 13.3 Pa (0.1 torr).
- semi volatile organic compounds
  - compounds having a saturated vapour pressure at 25°C between 13.3 Pa (0.1 torr) and 13.3 uPa (10^{-7} torr)
- non volatile organic compounds
  - compounds having a saturated vapour pressure at 25°C below 13.3 uPa (10^{-7} torr)

The non-organic compounds were grouped according to their chemical characteristics.

Table 2.1 lists the contaminants considered in this study and shows the categories into which the compounds are placed.

2.3 Scenarios Considered

Five abatement scenarios are considered. They include Scenario A which requires that control Level 2 (BACT-EA) is applied to most contaminant groups, a more stringent Scenario B under which control Level 1 (LAER) is applied to most contaminant groups and Scenario C for which a less stringent level of control, Level 3 (NSPS) is applied to most contaminant groups. In addition, two other scenarios are examined: a two-tiered Scenario D, and a phased-in Scenario E which is identical to Scenario A but implemented more slowly. The contaminant group and degree of control by scenario are shown in Table 2.2.

Phasing in for existing and new facilities are given at the bottom of Table 2.2 and indicate that under the proposed adoption schedule (Case 1), contaminants of high and medium toxicity Level 1 or 2 are to be controlled by 1994.

2.4 Other Regulations

For the purposes of this study, gaseous emissions from the INCO Sudbury Smelter Complex, the Falconbridge Smelter Complex and Ontario Hydro were not included nor costed because gaseous emissions are covered by separate regulations listed below.

O. Reg. 660/85 Inco Sudbury Smelter Complex - 1994
O. Reg. 661/85 Falconbridge Smelter Complex - 1994
O. Reg. 281/87 Ontario Hydro

Other emissions, such as particulates, from INCO, Falconbridge and Ontario Hydro are costed in this study.

2.5 Assumptions

Compliance

One hundred percent compliance with the existing Reg. 308 and the proposed revisions to Reg. 308 will be assumed in this study. In practice, this level of compliance would only be approached with a greatly enhanced monitoring and enforcement effort by MOE.

Incinerators of Non-Hazardous Wastes

The MOE has established policies for air pollution control on refuse incinerators and the combustion of refuse in incinerators. The policies require that 'state-of-the-art' air pollution control systems be installed on all new incinerators. Furthermore, the MOE is participating in the formulation of federal guidelines for municipal incineration. (Emission numbers have been developed but are not available.)

These new policy developments are independent of the proposed revisions to Reg. 308 and, to a large extent, anticipate the kinds of changes that the proposed revisions are intended to bring about. Therefore, it will be assumed that the changes to Reg. 308 will have no significant effect on the abatement technologies required for new incinerators of non-hazardous wastes.

Other Regulations

For the purposes of the economic assessment, and to be consistent with the thinking underlying the proposed revisions to Reg. 308, it will be assumed that the proposed revisions to Reg. 308 will not supercede the regulations on P. 55 of the CAP document (MOE, 1987) except where explicitly stated as doing so in the document (e.g. Reg. 296).

Other Jurisdictions

It will be assumed that Ontario is the only jurisdiction contemplating changes in the regulation of air pollution. Possible changes in other jurisdictions will not be considered.

Changes in Technology

Only those technologies that currently meet the criteria for Level 1 (LAER), Level 2 (BACT-EA) and Level 3 (NSPS) will be considered in the economic assessment.

Units of Measurement

Metric measures will be used for all units of mass, volume and distance unless otherwise stated. All monetary values will be expressed in 1986 Canadian dollars.

References

Lewis, R.G., 1986. "Problems Associated with Sampling for Semi Volatile Organic Chemicals in Air." Proceedings of the 1986 U.S. EPA/APCA Symposium on Measurements of Toxic Air Pollutants, Raleigh, North Carolina, April.

Ministry of the Environment (MOE), 1987. "Discussion Paper Air Pollution - General Regulation (Regulation 308)." November. CAP (Clean Air Program) Discussion Paper.

Table 2.1

CONTAMINANTS CONSIDERED

VOLATILE ORGANIC COMPOUNDS

Chlorinated

carbon tetrachloride
chloroform
ethylene dichloride
phosgene
vinyl chloride
trichloroethylene
1,1,1-trichloroethane (methyl chloroform)
epichlorohydrin
methylene chloride
perchloroethylene
hexachlorocyclopentadiene
4,4-methylene-bis-2-chlorol-aniline

Aliphatics

acrylonitrile	(nitrile)
ethylene	
ethylene dibromide	(alkyl halide)
mercury (alkyl)	(alkyl)
nickel carbonyl	(organo metal)

Aromatic

benzene
coal tar pitch volatiles (soluble fraction)
ethylbenzene
styrene
toluene
xylenes

Esters

butyl acrylate
ethylene glycol butyl ether acetate (butyl Cellosolve acetate)
ethylene glycol ethyl ether acetate (Cellosolve acetate)
propylene glycol monomethyl ether acetate

Table 2.1 (Continued)

Alcohols

Ethers

ethylene oxide
propylene oxide
ethylene glycol butyl ether (butyl Cellosolve)
ethylene glycol ethyl ether (Cellosolve)
propylene glycol methyl ether

Aldehydes

formaldehyde
propionaldehyde

Ketones

2-butanone (methyl ethyl ketone)
methyl isobutyl ketone

Mercaptans

mercaptans

Other

acrylonitrile
mercury alkyl
nickel carbonyl

PARTICULATES associated:

Organic

benzo(a)pyrene
thiourea

Metals

beryllium
cadmium
chromium
chromium (di, tri, and hexavalent forms)
lead
manganese compounds
nickel
calcium cyanide (as total salt)
potassium cyanide (as total salt)
sodium cyanide (as total salt)
tin

Table 2.1 (Continued)

OTHER PARTICULATES

- arsenic
- asbestos (fibres of length greater than 5 micrometers)
- asbestos (total)
- inhalable particulates (less than 10 micrograms)
- selenium
- silica-respirable (less than 10 micrometers in diameter)
- suspended particulate matter (particulate less than 44 microns in size)
- fluorides (total)

SEMI-VOLATILE ORGANICS

chlorinated dibenzo dioxins (CDDs)	(chlorinated)
mixture of chlorinated dibenzo dioxins and chlorinated dibenzo furans	(chlorinated)
phenol	(aromatic)
polychlorinated biphenyls	(chlorinated)
trichlorophenols	(chlorinated)
naphthalene	(aromatic)
pentachlorophenol	(chlorinated)
tetrachlorophenols	(chlorinated)
polycyclic aromatic hydrocarboons (PAHs)	(aromatic)
trichlorobenzenes	(chlorinated)
1,2,4-trichlorobenzene	(chlorinated)
pentachlorobenzenes	(chlorinated)
tetrachlorobenzenes	(chlorinated)
toluene diisocyanate	(aromatic)
methane diphenyl diisocyanate	(aromatic)

PESTICIDES

- captan
- chlordane

CORROSIVES

Acids

- hydrogen chloride
- hydrogen cyanide
- sulfuric acid
- propionic acid

Table 2.1 (Continued)

Bases

- ammonia
- potassium hydroxide
- sodium hydroxide

OTHER

- arsine
- chlorine
- chlorine dioxide
- mercury
- nitrogen oxides
- nitrous oxide
- ozone
- phosphine
- sulfur dioxide
- hydrogen sulfide
- total reduced sulfur (TRS) as equivalent H_2S (from Kraft Pulp Mills)

Table 2.2

CONTROL SCENARIOS

Contaminant Group	Scenarios A Initial	B More Stringent	C Less Stringent	D 2-Tier
Volatile Organic Compounds (Odorous and Non-Odorous)				
Chlorinated	1	1	2	1
Aliphatics	3	2	3	2
Aromatics	2	1	3	2
Esters/Alcohols/Ethers/ Aldehydes/Ketones	2	1	3	2
Mercaptans	3	2	3	2
Particulates associated:				
Organics	1	1	2	1
Metals	1	1	2	1
Other Particulates	2	1	3	2
Semi-Volatile Organics	2	1	3	2
Pesticides	2	1	3	2
Corrosives				
Acids	2	1	3	2
Bases	2	1	3	2
Other	2	1	3	2
Other	2	1	3	2

Phasing In:

Phasing in for each of the above scenarios will be as in case 1 below. A fifth scenario (E) will also be considered which is identical to scenario A, but is phased in more slowly (case 2).

Phasing In	**A,B,C,D Case 1**	**E Case 2**
New Facilities	**1989**	**1989**
Existing Facilities		
Contaminant Group:		
Level 1 (high hazard)	**1994**	**2004**
Level 2 (medium hazard)	**1994**	**2009**
Level 3 (low hazard)	**1994**	**2014**

Note:

Levels 1, 2 and 3 have been assigned for the purposes of this study only and may not reflect the actual levels of control imposed in any revisions to Reg. 308.

3.0 CONTINUOUS MONITORING

3.1 Introduction

This chapter deals specifically with the technology of continuous emission monitoring systems (CEMS) for gaseous process effluents. The information presented is largely drawn from information provided through the United States Environmental Protection Agency (U.S. EPA) via discussion and publications. Appendix A describes the components of a model utilized in this study to estimate the capital and operating costs of CEMS for different industry sectors.

3.2 Definition of Continuous Emission Monitoring System

A Continuous Emission Monitoring System (CEMS) is a device that will give a series of on-line measurements of the concentration of specific components that may be contained in a gaseous effluent. These components will usually be gaseous themselves at the point of measurement, but not always. One notable exception is opacity which is generated by suspended solid (or liquid) particulate.

Other characteristics that are often measured on a continuous basis include temperature, pressure, and velocity, but these have not been dealt with at any length in this report as the technology is readily available and relatively inexpensive.

Definitions of CEMS specific to particular industries have been produced by the U.S. EPA. For instance, under the Federal Register 40-CFR-60, subpart Da and Db, dealing with power utility and other stream-producing boilers, a continuous reading for NO_x, SO_2, CO_2, and O_2 is defined as a minimum of one reading every 15 minutes (60.13.e2). Opacity measurements, however, are defined as the six-minute average of readings taken at least every 10 seconds (60.13.e1). In the case of total reduced sulfur (TRS) measurements in the Kraft pulp industry, the minimum requirement for CEMS recording intervals appears to be one reading per hour. It is noteworthy that the particular definition of "continuous" influences the characteristics of the type of monitor that must be employed in any given circumstance.

CEMS requirements common to most industries are performance specifications such as once daily zero and span checks. Further specifications for any given CEMS deal with both accuracy and reliability.

For both the above requirements the U.S. EPA have produced industry-specific guidelines. Under subpart Da and Db of 40-CFR-60, the requirements for operation of the system (60.47.f), the minimum data-producing time for a system is defined as:

1) 18 hours out of any 24 consecutive hours
2) 22 days out of 30 consecutive days

In addition to this requirement, a recent enactment, Appendix F of 40-CFR-60 (December 1987), now requires that these systems submit to quarterly audits that will physically check their accuracy against known reference standards.

At present, only a limited number of CEMS are installed and operational in the U.S. according to these definitions. For the purposes of this document, it is assumed CEMS utilized in Ontario under the proposed revisions to Reg. 308 will satisfy the most stringent U.S. EPA specifications.

3.2.1 History of CEMS in North America

In North America the use of CEMS has been controlled by a variety of local industries and agencies. Although there have been long standing requirements for both process and stack gas monitors in many jurisdictions, a consistent overall set of rules has been conspicuously lacking.

The first universal rules for the United States were set out by the U.S. EPA in 1971. These were specifically related to large utility boilers over 250 Mbtu/h (subpart D) and they specified the need for continuous monitors for SO_2 and NO_x and a reference gas, usually O_2 or CO_2. They did not, however, define the system to be installed, nor its operating characteristics.

In 1975, a set of rules and reference methods for CEMS on large utilities were prescribed under Appendix B of 40-CFR-60. Among the items specified by these rules was a 168-hour performance test.

Until 1978, none of the CEMS under subpart D were to be used as compliance monitors, and regardless of whether they produced high readings, no action could be taken by the U.S. EPA. A manual reference was required to prove lack of compliance.

In 1978, under subpart Da, the U.S. EPA made CEMS mandatory as compliance monitors on large utility boilers built thereafter. At that time, the minimum operating performance of a CEMS was also defined such that compliance could be determined both on accuracy (based on the 168-hour test) and operating time.

In 1984 the preceding legislation under subpart Db was also made applicable to smaller power boilers (larger than 100 Mbtu/h) built after 1984. The final legislation enacted to date is Appendix F of 40-CFR-60. Implemented in December 1987, it requires that all CEMS set out under subpart Da and Db undergo a Quality Assurance and Quality Control (QA/QC) program that includes quarterly audit checks as part of the compliance program. These checks consist of independent calibrations using standard reference methods and/or gases.

At this time it seems that the U.S. EPA has developed a full set of regulations to define what constitutes a compliance CEMS for power boilers over 100 Mbtu/hr. The readings from the CEMS must be regularly reported to the U.S. EPA (or appropriate authority) and any exceedences recorded. A lack of monitor operation is a violation of the regulations.

Although CEMS are required by the U.S. EPA for some other industries, these monitors have not been treated as compliance units.

CEMS are required (as of 1983) in the following industries:

Subpart	Process	Continuous Monitor
G	HNO_3 Manufacture	NO_x
H	H_2SO_4 Manufacture	SO_2
J	Petroleum Refineries	Opacity, CO, SO_2
P	Primary Copper Smelters	Opacity, SO_2
Q	Primary Zinc Smelters	Opacity, SO_2
R	Primary Lead Smelters	Opacity, SO_2
AA	Steel Plants, Electric Arc Furnaces	Opacity
BB	Kraft Pulp Mills	Opacity, TRS

3.2.2 Current Situation of CEMS in the U.S.

At the present time it is estimated that most CEMS have been installed by utility industries both before and after subparts D, Da, and Db. Of these installations, the majority are opacity systems, followed by SO_2 CEMS. An approximate breakdown of operating units is as follows (Peeler, 1988):

System	Units Operating
Opacity	3000 - 4000
SO_2 before 1971	2000, only 1000 potentially viable
SO_2, NO_x, after 1975	300 - 500, 100 - 200 accurate
Subpart Da - 1978	30 units maximum
Subpart Db - 1984	50 - 70 units, 10 applications/ month

Although this list primarily includes utility boilers, a considerable number of other CEMS exist. These include, for example, monitoring TRS in Kraft pulp facilities and other industries.

In conclusion, although the U.S. EPA has had nearly 20 years of CEMS legislation in place, the number of fully regulated and documented systems operating is quite small, and of recent origin. Because the U.S. EPA has produced its rules in a piecemeal and sequential manner, the adoption of accurate and reliable monitoring systems has been slow. A proliferation of equipment types and system designs has occurred (especially during the early 1970s) but as yet no preferred technologies are apparent.

Most emission information has been obtained from the utility industry where monitoring has concentrated on opacity, SO_2, NO_x, O_2, and CO_2. Other areas of monitoring such as organics and hydrogen chloride have not yet been well-developed, although there have been recent improvements especially for HCl. It is not anticipated that specific organic compound monitors will be developed or be required for some time, but there may be some demand for generic monitors.

3.2.3 Summary of Current Position and Future Expectations for CEMS

At the present time the U.S. EPA has performance specifications for the following equipment:

Opacity Monitors, SO_2, NO_x, CO, O_2, CO_2 and TRS Instruments

These are documented under Appendix B of 40-CFR-60. Standard accuracy tests (compliance tests) for this equipment are documented under Appendix A of 40-CFR-60.

For control systems requiring CEMS, the performance tests and relative accuracy must be met in a one-time test to certify the system. The CEMS does not represent a compliance test, and as a result, deviations from emission specifications detected by the monitoring equipment are not used to determine compliance violations.

The only control systems currently required to meet compliance are the subpart Da and Db systems on boilers. These generally require opacity, NO_x and/or SO_2 and a reference gas (CO_2 or O_2).

The preceding systems must not only be certified initially, but must now undergo quarterly audit checks for accuracy (Appendix F of 40-CFR-60). Deviations either in operation or emissions will result in automatic violations. Automatic reporting of data to regulatory authorities is a requirement.

In essence two types of CEMS have developed in the U.S., namely compliance and noncompliance. In general the minimum reliability and accuracy of the compliance system needs to be much higher than noncompliance systems and hence they will be more expensive.

In the U.S., due to the long time span of regulatory enactment, early systems of noncompliance quality were allowed to freely compete with compliance systems and hence both obtained credibility. Recently, however, as compliance CEMS have come to be requisite in the power boiler industry, many of the earlier noncompliance systems have been replaced, and a consistent set of compliance CEMS is beginning to develop.

Other industries have similar monitoring requirements (i.e. NO_x, SO_2 etc.) and some of the CEMS technology can be expected to be transferred. It is also expected that sources currently requiring noncompliance CEMS will eventually be controlled as compliance sources. Hence, over the long term only the family of compliance CEMS will proliferate across industries.

3.3 Assumptions Used for CEMS Quality in This Report

General

1. Any CEMS will be used as a compliance monitor.

2. Compliance specifications and quality control audits as per U.S. EPA regulations under 40-CFR-60 subpart Da, Db and associated Appendices A, B and F will be in place and have to be met.

3. Only proven technology will be considered.

4. Costs will be broken down as, where possible:
    - i) analytical instrument(s)
    - ii) sample extraction and conditioning
    - iii) data acquisition system and calibration control
    - iv) influence of multisource systems
    - v) certification

vi) maintenance
vii) reporting
viii) auditing

(i) through (v) represent capital costs, and (vi) through (viii) are operating costs.

5. Where possible extrapolations from known technology to required sources will be attempted.

3.3.1 Types of CEMS

Most CEMS consist of an analytical monitor that actually responds to the component to be measured (SO_2, NO_x opacity etc.), a system to present a sample of the gas to the analyser, and a data processing system to produce the required numerical results.

Two principal types of systems are marketed, one in which the monitor is essentially at the source (in situ), and the other in which the monitor is removed from the source and the gas sample is delivered to it (extractive).

In situ analysers place most of their sensitive components at the source and therefore eliminate most or all of the sample delivery and conditioning system required by the same analyser when used extractively. They often have a price advantage for a single gas, single source requirement. For many industries multiple sources have to be sampled, and these can often be done by time sharing extractive systems, in which multiple sample delivery systems are connected to a central analyser system.

A constraint that has been placed on potential systems is the ability to validate the readings effectively and inexpensively. In effect, at least for SO_2, NO_x, CO_2, CO and O_2 monitors, this requires the ability to calibrate with direct injection of standard cylinder gases.

As a result of this requirement cross beam gas analysers other than opacity have been considered unacceptable as CEMS in this study, and therefore are not considered.

References

U.S. Environmental Protection Agency (U.S. EPA), 1989. Personal Communications and numerous publications on CEMs.

Peeler, J., 1988. Personal Communication. Entropy Inc., Research Triangle Park, N.C., March.

4.0 STACK SAMPLING

4.1 Sampling and Analytical Methodologies

This section is largely based on standard reference sampling and analytical methodologies and draft protocols currently in use by the MOE, the Environmental Protection Service (EPS), the U.S. Environmental Protection Agency (U.S. EPA) and various state agencies.

For those contaminants where no standard reference methodologies exist or the applicability of existing methodologies is vague, standard methodologies utilized for similar compounds were assumed to be applicable.

To measure the emissions of air pollutants from a stationary source, standard reference sampling protocols essentially employ the use of one of the five following sampling systems:

- Method 5 Sampling Train (MOE, EPS, U.S. EPA)
- Modified Method 5 Sampling Train (EPS, U.S. EPA)
- Volatile Organic Sampling Train (U.S. EPA)
- Grab Sampling Train (U.S. EPA)
- Continuous Analyser Sampling Train (MOE, U.S. EPA)

4.1.1 Method 5 Sampling Train

The Method 5 sampling train, originally developed by the U.S. EPA with subsequent protocols developed for Canada and Ontario by the EPS and MOE respectively, is used primarily to determine the concentration of particulate matter and the emission rate of a gas stream from a stationary source. The Method 5 test method is in fact a compilation of Methods 1 through 5 (MOE source test code) designed to determine the location of the source sampling site and sampling points, the velocity and volumetric flow rate of the gas stream, the gas molecular weight and moisture content of the gas stream, as well as the particulate concentration and emission rate.

Commercially available Method 5 sampling trains generally are comprised of the following individual components:

1) Probe Nozzle
2) Probe
3) Pitot tube
4) Temperature sensor
5) Differential pressure gauges
6) Filter holder (in-stack or out-of-stack types)
7) Miniature cyclone (optional)
8) Filter and cyclone heating system
9) Metering system
10) Impinger - condenser system
11) Barometer
12) Gas composition determination equipment (Methods 3 and 4)

Standard reference methodologies using the Method 5 sampling train also exist for measuring pollutants such as asbestos, silica (<10 um dia), metals and various inorganics. Modifications to the Method 5 train that enable measurement of such pollutants include the use of in-stack cyclones, specialized filters and appropriate impinger solutions.

A variety of standard analytical methodologies also exist for pollutants collected using the Method 5 sampling train.

Metals such as arsenic, beryllium and lead are analyzed using the principle of Inductively Coupled Argon Plasma Spectroscopy (ICAP) or Atom Absorption Spectroscopy (AAS). Mercury is analyzed using

Cold Vapour Atomic Absorption Spectroscopy (CVAAS).

The standard reference method used to count asbestos fibers uses the principle of optical-phase-contrast microscopy while silica is analyzed using the principle of x-ray diffraction.

Many of the inorganics collected using the Method 5 sampling train are analysed using ion chromatographic, specific ion electrode, colormetric, or titration methodologies.

4.1.2 Modified Method 5 Sampling Train (MM5)

The Modified Method 5 (MM5) sampling train is designed to collect organic compounds with boiling points greater than 100°C. The train, as the name suggests, is adapted from the Method 5 sampling train mentioned previously. The basic modification is the inclusion of a sorbent module of porous polymeric resin (typically XAD-2) to adsorb semivolatile organic species. The filter is used to collect organic-laden particulate materials while remaining organics are trapped on the sorbent. Standard reference methods incorporating the MM5 train have been developed for organics such as Polycyclic Aromatic Hydrocarbons (PAHs), Chlorinated Dibenzo Dioxins (CDDs), Chlorinated Dibenzo Furans (CDFs), Polychlorinated biphenyls (PCBs), Chlorobenzenes, and Chlorophenols.

Reference analytical methodology for organics is normally based on gas chromatographic (GC) principles. The costs involved in GC analysis depend largely on the level of detection required. For high profile pollutants such as dioxins and furans in which extremely low detection limits are necessary, analyses are performed using the principle of gas chromatography/mass spectrophotometry (GC/MS). This analytical method, both from the analysis itself and the high degree of QA/QC required in sample preparation and proofing, can be significantly more costly than GC analysis alone. For other organics the decision of performing GC or GC/MS analysis is largely a matter of choice. It is assumed that all organic substances considered in this report are priority pollutants and therefore necessitate analysis by GC/MS.

4.1.3 Volatile Organic Sampling Train (VOST)

The Volatile Organic Sampling Train (VOST) is a recent U.S. EPA developed train to collect vapour phase organic compounds with boiling points in the range 30-100°C. The collection system of the train consists of a series of condensers and sorbent cartridges containing either Tenax resin or Tenax resin/petroleum based charcoal.

Although the VOST system is ideally applicable to organic compounds with boiling points in the range 30-100°C, VOST may also be appropriate for certain organic compounds with boiling points between 100-140°C. Since the MM5 train can also be used to measure these organics, the train used depends on the organic(s) to be sampled, source process conditions, cost of sampling and analysing and, ultimately, on governmental agency decisions.

In addition, careful attention must be made to organics with boiling points less than 30°C since such organic compounds may break through the sorbent material and produce questionable results.

Organic species ideally suited to VOST sampling include acrylonitrile, benzene, carbon tetrachloride, chloroform, ethylene oxide, and toluene.

As with MM5 sampling train methodology, analytical methodology for VOST organics is normally based on gas chromatographic (GC) principles. Again, it is assumed that all organics sampled using VOST methodology require analysis by GC/MS.

4.1.4 Grab Sampling Train

The grab sampling train is the simplest of all the trains mentioned and consists of a grab system (probe, sample line, pump) and a collection container (tedlar bag, glass bulbs, etc.). Several U.S. EPA standard reference protocols use this sampling technique for measuring common gaseous pollutants such as sulfur dioxide, nitrogen oxides, organics, and vinyl chloride. It should be noted these pollutants can also be measured using more accurate methodologies such as Method 5, MM5, VOST or continuous analysing. Most compliance testing programs therefore, with the possible exception of vinyl chloride, will advocate the use of sampling methodologies other than grab sampling.

Grab samples are typically analysed by gas chromatography (GC).

4.1.5 Continuous Analyser Sampling Train

As with the grab sampling train, several MOE and U.S. EPA standard reference protocols use continuous analysers for measuring contaminants emitted from stationary sources. Methodologies exist for pollutants such as total hydrocarbons, sulfur dioxide, total reduced sulfur and nitrogen oxides. Included in each of the reference methodologies are provisions to ensure proper analyser operation and calibration. Nevertheless, the use of continuous analysers as acceptable compliance methodologies can be industry specific. In cases in which a protocol exists for using a continous analyser, as well as one or more alternative sampling methodologies, it is assumed that a continuous analyser will be selected.

Appendix B to this report sets out the procedure employed to estimate stack sampling costs.

5.0 AMBIENT AIR QUALITY MONITORING

5.1 Introduction

Developing sampling and analytical methods for each of the contaminants for which an ambient air quality criterion is proposed is a difficult task. Since virtually every air monitoring program concerns different compounds of interest, a variety of techniques is required to cover the range of components. In addition, unique requirements in terms of specificity, detection limits, analysis time, and other performance characteristics may require modification of existing methods.

The following primary sources of sampling and analysis methods were reviewed in determining the technologies that are currently available:

- Ontario Ministry of the Environment Ambient Air Quality Monitoring Protocols (MOE, 1979 to 1984)
- Environment Canada Standard Reference Methods for the Measurement of Air Contaminants (EPS, 1972 to 1987)
- Environmental Protection Agency (U.S. EPA) Reference Methods
- Technical Assistance Document for the Sampling and Analysis of Toxic Organic Compounds in Ambient Air (U.S. EPA, 1983)
- Compendium of Methods for the Determination of Toxic Organic Compounds in Ambient Air (U.S. EPA, 1984)
- Supplement to EPA/600/4-84/041: Compendium of Methods for the Determination of Toxic Organic Compounds in Ambient Air (U.S. EPA, 1987)
- National Institute for Occupational Safety and Health Methods (NIOSH, 1984 and 1987)
- American Society for Testing and Materials Methods (ASTM, 1988a, 1988b)
- Testing Guidelines for Solid Waste Disposal Sites,

California Air Resources Board (CARB, 1986)

- Quality Assurance Handbook for Air Pollution Measurement Systems, Volumes I to IV (U.S. EPA, 1977 to 1988)

Technology for monitoring conventional pollutants is well-established and proven. Sampling and analytical methodologies are briefly outlined in the pages ahead for the following conventional pollutants:

- Sulphur Dioxide (SO_2)
- Total Suspended Particulate Matter (TSP)
- Carbon Monoxide (CO)
- Ozone (O_3)
- Nonmethane Hydrocarbons
- Nitrogen Dioxide (NO_2)
- Lead
- Particles less than or equal to 10 um (PM10)

However, sampling and analytical methodologies are not well-established for other pollutants, but are still evolving. In these cases emphasis has been placed on evaluating available techniques for the monitoring of air toxics and their applicability for ongoing use by industry.

Also outlined in this chapter are sampling and analytical considerations, and generic and specific methods for air toxics. Because of the restraints discussed herein, specific methods may not be applicable for all of the compounds that have been listed by the MOE (MOE, 1989). The applicability of each specific method has not been reviewed to determine if the methodology supports the proposed ambient standard. Many of the NIOSH/OSHA methods presented do not meet ambient monitoring criteria and many need to be modified or changed to achieve lower detection limits.

Appendix E of this report identifies sampling and analytical methods for the compounds in the list of proposed ambient air standards in the CAP discussion paper (MOE, 1987).

5.2 Conventional Pollutant Monitoring

With the realization that air pollution could be a significant concern, researchers and regulators in the United Kingdom, the United States and other industrialized countries began major efforts to reduce air pollution a number of years ago. Part of these efforts entailed the development of techniques to measure the levels of pollutants in the atmosphere. Initially, the primary pollutants of concern were what have been termed conventional pollutants: sulphur dioxide, total suspended particulate matter, carbon monoxide, and nitrogen oxides. As the science progressed and photochemical smog was identified as a problem, ozone and hydrocarbons were added to the list; lead was added when the toxicity and widespread elevated levels were recognized. More recently the techniques for small (<10 um) particulate matter have also been added.

The development of monitoring techniques in Canada and in the United States has progressed in parallel. As a result, in most cases the standard reference methods of the two countries are very similar. However, in recent years the efforts expended in the United States with respect to quality assurance and quality control have exceeded those in Canada.

The following standard reference methods have been published by Environment Canada.

- Standard Reference Method for the Measurement of Sulphur Dioxide in the Atmosphere (West-Gaeke Method), (EPS, 1972)
- Determination of Airborne Particulate Manganese by Atomic Absorption Spectrophotometry, (EPS, 1972a)

- Standard Reference Method for the Measurement of Carbon Monoxide in the Atmosphere (Non-Dispersive Infrared Spectrometry), (EPS, 1973a)
- Standard Reference Method for the Measurement of Suspended Particulates in the Atmosphere (High Volume Method) (EPS, 1973b)
- Standard Reference Method for the Measurement of Ozone in the Atmosphere (Chemiluminescence Method) (EPS, 1981)
- Standard Reference Method for the Measurement of Nitrogen Dioxide in the Atmosphere (Chemiluminescence Method) (EPS, 1974)
- Standard Reference Method for the Determination of Lead in Airborne Particulates (Atomic Absorption Spectrophotometry) (EPS, 1976)
- Standard Reference Method for Ambient Testing: Hydrogen Sulphide (EPS, 1984)

In addition, the MOE has developed a number of monitoring protocols for conventional pollutants (MOE, 1979-1984).

REPORT #AMP-101	December 1979	Method for High Volume Sampling and Determination of Total Suspended Particulate Matter in Ambient Air
REPORT #AMP-105	December 1979	Method for the Determination of Heavy Metals in Total Suspended Particulate Matter in Ambient Air

REPORT #AMP-113	March 1981	Method for the Sampling and Determination of Sulphur Dioxide in Calibration Gases by the Pararosaniline Colourimetric Procedure
REPORT #AMP-118	March 1981	Method for the Continuous Sampling and Determination of Sulphur Dioxide in Ambient Air by Fluorescence
REPORT #AMP-120	March 1981	Method for the Continuous Sampling and Determination of Ozone in Ambient Air by Chemiluminescence
REPORT #AMP-121	March 1981	Method for the Continuous Sampling and Determination of Nitrogen Dioxide and Nitric Oxide in Ambient Air by Chemiluminescence
REPORT #AMP-123	October 1981	Method for the Sampling and Determination of Carbon Monoxide in Ambient Air by Non-Dispersive Infrared Spectrometry

The following methods for conventional pollutants have been established by the U.S. EPA as Reference or Equivalent methods and are published in the Title 40 Code of Federal Regulations (CFR) Part 50, Appendices A-J:

- Reference Method for the Determination of Sulphur

Dioxide in the Atmosphere (Pararosaniline Method)

- Reference Method for the Determination of Suspended Particulate Matter in the Atmosphere (High Volume Method)
- Measurement Principle and Calibration Procedure for the Measurement of Carbon Monoxide in the Atmosphere (Non-dispersive Infrared Photometry)
- Measurement Principle and Calibration Procedures for the Measurement of Ozone in the Atmosphere
- Reference Method for the Determination of Hydrocarbons Corrected for Methane
- Measurement Principle and Calibration Procedure for the Measurement of Nitrogen Dioxide in the Atmosphere (Gas Phase Chemiluminescence)
- Reference Method for the Determination of Lead in Suspended Particulate Matter Collected from Ambient Air
- Reference Method for the Determination of Particulate Matter as PM10 in the Atmosphere

5.3 Other Pollutant Monitoring

As previously stated, sampling and analytical methods for other pollutant monitoring are not well-established and are frequently changing. This section discusses both generic and specific information regarding sampling and analysis techniques.

5.3.1 Method Performance

Required analytical method performance must be considered in the early planning stage as performance elements have a significant effect on the cost and success of a project. Sufficient performance criteria should be defined to support the intended use of the data. Potential limitations to data utility and use should be identified and stated. The major method performance elements to be considered are:

- Detection/Quantitation Limits
- Accuracy and Precision
- Interferences
- Analysis time

Detection/Quantitation Limits

Detection limits are defined in many ways. Two definitions which need to be clearly distinguished are limits of detection and limits of quantitation.

Limits of detection describe the sensitivity of the instrument to a particular analyte, independent of the sample collection, handling, and preparation processes. Limits of detection are defined as the lowest amount of an analyte that is statistically distinguishable from a blank.

Limits of quantitation describe the sensitivity of an analytical method to a particular analyte, including the sample collection, handling, and preparation processes. Limits of quantitation are defined as the lowest level of concentration above which quantitative results may be obtained with a specified degree of confidence.

Because losses of the target analytes are inevitable in the sample collection and analysis process, the limit of quantitation is a more realistic parameter for consideration in the evaluation of method performance.

If available analytical methods cannot detect the target analytes at desired concentrations, then one must undertake sometimes costly method development or reduce the program performance requirements to allow partial fulfillment of the objectives.

Accuracy and Precision

Accuracy is an indicator of the bias, or error in a measurement system. Sources of error are the sampling process, sample handling, contamination, sample preparation, sample matrix, and analysis techniques. Sampling accuracy may be assessed by evaluating blanks. Analytical accuracy is determined by the use of quality control (QC) samples under conditions duplicating the sampling and analysis procedures.

An evaluation of accuracy must be compatible with the intended use of the data. For example, if the goal is to compare the relative concentration of target constituents at an individual site using the same analysis procedures, then low accuracy performance may be acceptable. However, if the goal is to compare concentrations of target constituents between participating laboratories or over a long time span, then absolute accuracy is an important criterion.

Precision measures the reproducibility of measurements under a given set of conditions. It is a quantitative measure of the variability of a group of measurements compared to their average value. The overall precision of measurement data is a mixture of sampling and analytical actors. When a method is precise, then fewer measurements are needed to attain a given degree of confidence in the data.

Accuracy and precision are often difficult to assess because the extent and quality of historical technical information is limited. One way to overcome this problem is to extrapolate performance criteria from a similar method. Then, as sample data becomes available, the method performance is re-evaluated in comparison to the stated data goals.

Interferences

The potential of interference by non-target constituents for a method must be identified and stated.

In some methods, interferents may affect quantitation accuracy by co-eluting with target constituents. Interferents may also conceal the presence of trace level target constituents or produce false positive results.

Many analytical methods allow the analysis of many chemically similar target constituents by a single method. When interferents are present the number of target constituents that can be detected or quantified may be reduced.

One way to address the problems cause by interferences is in the proper selection of sample collection and preparation techniques. Proper technique choice permits the isolation of target constituents from non-target, interfering constituents.

Analysis Time

Analysis time must be considered when the sample collection and analysis is being performed continuously and narrow time resolution is required. In this case, the resolution time requirement will limit the methods that can be used.

5.3.2 Selection of Sampling and Analytical Methods

The availability of suitable sampling and analysis techniques is often limited. A variety of methods may be required to cover the extensive range of target constituents, resulting in a significant cost impact. In addition, unique requirements in terms of specificity, detection limit, analysis time, and other performance elements may require modifications to existing methods. Factors to be considered in selecting sampling and analysis methods are:

- Physical and chemical properties of compounds
- Relative and absolute concentrations of compounds
- Method performance characteristics
- Time resolution or requirements
- Cost constraints

Physical and Chemical Properties of Compounds

The important chemical and physical properties to be considered include thermal stability, volatility, polarity, ionic character, phase distributions, and chemical composition.

Thermal stability, volatility, polarity, and ionic character are properties that are used to evaluate the suitability of particular chromatography techniques. They must also be considered in the selection of preparation techniques that may result in the loss or degradation of compounds.

Phase distribution (gas/particle) is important because sample collection, preparation, and analysis techniques may be different for particle bound compounds than for gas phase compounds. Compounds which are present in both phases require special considerations.

Chemical properties are important in assigning target analytes to specific analytical groups that take advantage of chemically specific analytical techniques.

Relative and Absolute Concentrations of Compounds

Target constituents present in high concentrations may be candidates for field analytical techniques that require little or no sample preparation. However, high concentration constituents may prohibit the quantitation of trace level constituents.

Low concentration constituents may require use of sample concentration techniques, and may be subject to greater interferences in analysis.

Method Performance Characteristics

Method performance characteristics have been discussed above. The ultimate use of the data will determine the performance requirements.

Time Resolution Requirements

Certain sampling techniques cannot accumulate sufficient quantity of sample for analysis to achieve the desired detection limits in the available sampling period. If extremely fine time resolution is required, then continuous monitors may be the only alternative.

Cost Considerations

The cost of purchasing,installing, operating, and maintaining an ambient air monitoring program is a significant non-technical factor which must be considered in program planning. Equipment purchase and installation costs can be accurately predicted with little difficulty once methods have been selected. Obtaining realistic estimates of program operating and maintenance costs is one of the most difficult aspects of program planning but is one of the most important factors in ensuring program success. program planners must not be tempted to select a "best case" scenario for estimating ongoing operations, maintenance, evaluation, and system auditing costs.

5.3.3 Specification of Quality Assurance Protocols

The monitoring program quality assurance (QA) plan should be prepared after the sampling strategy and sampling and analytical methods have been defined. The primary parts of a QA plan are management, sampling QA, analytical QA, and data reduction QA.

To select the optimal sampling technique for the proposed ambient air contaminants, the effect that physical and chemical properties of the compounds can have on the sampling process must be considered. Important physical properties such as boiling point, vapour pressure, water solubility, and solubility in various solvents, should also be considered. Chemical properties of concern include thermal stability, reactivity with water or other common constituents in ambient air, and photochemical reactivity.

5.4 Generic Methods for Air Toxics

Section 5.3 has provided an overview of the issues to be considered in sammpling and analysis of nonconventional air pollutants. These other/nonconventional pollutants are generally referred to as "air toxics" in the current literature, although the presumption of "toxic" effects of a compound's presence in ambient air may not be appropriate in every situation. Section 5.4 discusses the generic analytical methods available for these and other compounds.

5.4.1 Methods for Gas Phase Components

Compounds that are predominantly in the gaseous phase at ambient temperature and pressure are generally sampled by passing the sample through a filtration device to remove particulate material before the gaseous components are captured. The sampling techniques commonly used for the gas phase components are:

- Solid Adsorbents
    - Organic Polymers (Tenax, XAD-2)
    - Inorganic (Silica gel, Florisil)
    - Carbon (Activated Carbon, Carbon Molecular Sieves)
- Cryogenic Trapping
- Impingers
- Whole Air Collection (Canisters, Tedlar Bags, Glass Bulbs)
- Derivatization Techniques

It may be possible to use direct reading gas chromatographs (GCs), thus circumventing the need for the capture process. The use of direct reading GC's requires substantially more equipment and expertise because of the low ambient concentrations typically measured.

5.4.2 Methods for Particle Phase Components

Nonvolatile (boiling point >200°C) and polar compounds may exist partially or exclusively on the surface of suspended particulate matter. An important part of particle sampling for trace organic analysis is the need for a gas phase collection device (e.g., impinger, adsorbent) downstream of the particle sampler. The available methods for particle sampling are:

- Filtration
    - Cellulose Fiber

  - Glass or Quartz Fiber
  - Teflon Coated Glass Fiber
  - Membranes
- Centrifugal Collection (Cyclones, etc.)
- Impaction
- Electrostatic Precipitation

5.4.3 Field Screening Techniques

Field screening techniques are techniques that can be accomplished rapidly in the field with relatively inexpensive instrumentation. This excludes devices such as mobile mass spectrometers (MS) and gas chromatography (GC) systems which are very expensive. The available screening approaches can be broadly classified as:

- Colourimetric methods
- Spectroscopic devices
- Ionization devices
- Photometric devices

5.5 Analytical Methods for Air Toxics

5.5.1 Gas Chromatography (GC)

GC is by far the most widely employed analytical technique in the monitoring of toxic organic compounds in ambient air. The sensitivity, specificity, and versatility of GC, coupled with the relatively volatile nature of most compounds in ambient air, make it a very attractive technique. GC is a technique that separates components of a sample by differential distribution between a gaseous mobile phase (usually helium, nitrogen, or hydrogen carrier gas) and a solid or liquid stationary phase held in a glass or metal column. The sample is injected into the carrier gas as a sharp plug and individual components are detected as they elute from the column at characteristic "retention times" after injection. Both column temperature and carrier gas flow must be carefully controlled to obtain uniform response and retention time characteristics.

Table 5.1 lists some common GC detectors, the compounds they detect and their respective advantages and disadvantages. Table 5.2 lists some useful dual GC detector combinations. The use of dual detectors increases the number of compounds which can be identified in a given GC analysis. Detector limitations such as sensitivity, vulnerability to contamination, and daily drift are not, unfortunately, overcome in all dual detector systems.

5.5.2 Gas Chromatography-Mass Spectrometry (GC-MS)

In principle, GC-MS can be viewed as another detection mode for gas chromatography. However, in practice, GC-MS is a highly sophisticated and powerful technique requiring more specialized skills and knowledge than other forms of GC. A detailed discussion of GC-MS theory and practice is beyond the scope of this document.

5.5.3 High Performance Liquid Chromatography (HPLC)

HPLC is a technique primarily designed for the detection of polar nonvolatile compounds the prescence of which is not readily detected by gas chromatography. At present HPLC is not widely used for ambient air monitoring, because most compounds of interest are relatively volatile. Two specialized cases where HPLC is useful for ambient air monitoring are:

- Determination of nonvolatile material such as polycyclic aromatic hydrocarbons (PAHs) in ambient particulate material

- Determination of reactive components such as aldehydes by reacting the compounds with a derivatizing agent

5.5.4 Thin Layer and Column Chromatography

Column chromatography and thin layer chromatography (TLC) are widely used as "cleanup" techniques prior to GC-MS, GC, or HPLC determination and are no longer widely used as determinative techniques in ambient air monitoring. The few methods where these techniques have been used for compound determination, such as PAH analysis, have been largely replaced by HPLC methods. However, in some cases such as benzo(a)pyrene analysis in ambient air, TLC has remained a viable technique because of its lower cost compared to HPLC. Both TLC and column chromatography are forms of adsorption chromatography.

5.6 Specific Toxic Sampling Methods

Environment Canada has proposed a draft sampling protocol for polycyclic aromatic hydrocarbons in ambient air. This procedure is a high volume, polyurethane foam (PUF) based sampling system.

The MOE has published a number of specific monitoring protocols for other pollutants which are listed below (MOE, 1979-1984).

Acetylene
Aliphatic Alcohols
Arsenic
Benzene
Bromodichloromethane
n-Butane
n-Butene
Carbon Tetrachloride
Chloroform
Isobutylene
Methane
Methyl Chloride
Methylene Chloride
Nitrate in Total Suspended Particulate Matter
Octane
Particulate Fluoride
Pentane

Chlorodibromomethane
Cumene
Cyclohexane
Cyclopropane
n-1-Decene
1,1-Dichloroethylene
1,2-Dichloroethylene
Ethane
2-Ethyl-1-Hexanol
Ethyl Acrylate
Ethylene
Ethylene Dichloride
Ethylbenzene
Fluoride in Vegetation
Gaseous Fluoride
Heptane
Hexane
n-Hexane
Polychlorinated Biphenyls
Propane
n-Propylbenzene
Propylene
Psuedocumene
Styrene
Sulphate in Total Suspended Particulate Matter
Tetrachloroethylene
Toluene
Toluene-2,4-Diisocyanate
Total Reduced Sulphur
Trichloroethylene
1,3,5-Trimenthylbenzene
1,2,3-Trimethylbenzene
Vinyl Acetate
Vinyl Chloride
Xylenes

The following methods published in "Compendium of Methods for the Determination of Toxic Compounds in Ambient Air" (U.S. EPA, 1984) are commonly used to sample toxic organic compounds in the atmosphere:

TO-1	Tenax GC Adsorption and GC/MS Analysis
TO-2	Carbon Molecular Sieve Adsorption and GC/MS Analysis
TO-3	Cryogenic Trapping and GC/FID or GC/ECD Analysis
TO-4	High Volume PUF Sampling and GC/ECD Analysis
TO-5	Dinitrophenylhydrazine Liquid Impinger Sampling and HPLC-UV Analysis

TO-6	High Performance Liquid Chromatography
TO-7	Thermosorb/N Adsorption
TO-8	Sodium Hydroxide Liquid Impinger with HPLC/UV
TO-9	High Volume PUF Sampling with HRGC/HRMS
TO-10	Low Volume PUF Sampling and GC/ECD Analysis
TO-11	Formaldehyde Determination Using Adsorbent Cartridges with HPLC Detection
TO-12	Nonmethane Organic Compounds Using GC/FID
TO-13	Determination of PAHs Using GC and HPLC
TO-14	Determination of VOCs Using SUMMA Passivated Canisters and GC Analysis

Legend for Abbreviations

ECD	electron capture detector
FID	flame ionization detector
GC	gas chromatography
HPLC	high performance liquid chromatography
HRGC	high resolution gas chromatography
HRMS	high resolution mass spectrometry
MS	mass spectrometry
PAHs	polyaromatic hydrocarbons
PUF	polyurethane foam

Method TO-1 is used to collect certain volatile organic compounds (e.g., aromatic and chlorinated hydrocarbons) on Tenax resin and subsequent analysis by GC-MS. Compounds that can be determined by this method are nonpolar organics having boiling points in the range of approximately 80° to 200°C. However, not all compounds falling into this range can be determined. Compounds for which this method has been used are listed below. The compounds are listed in the order in which they appear in the method summary table. Compounds are generally listed in order of increasing column retention time and chemical class (nonchlorinated, chlorinated, brominated, etc.). This is generally true of the compound listing for each Toxic Organic (TO) method.

Benzene
Toluene
Ethyl Benzene
Xylene(s)
Cumene
n-Heptane
1-Heptene
Chloroform
Carbon Tetrachloride
1,2-Dichloroethane
1,1,1-Trichloroethane
Tetrachlororethane
Trichloroethylene
1,2-Dichloropropane
1,3-Dichloropropane
Chlorobenzene
Bromoform
Ethylene Dibromide
Bromobenzene

Other compounds may be successfully quantified by this method. Howver, it will be necessary to demonstrate the validity of the method through use of spiked samples, standard gases, etc., prior to analysis. Such validation activity will be part of the analytical projects Quality Assurance/Quality Control Plan.

Method TO-2 is used to collect certain highly volatile organic compounds on a carbon molecular sieve (CMS). Compounds that can be determined by this method are nonpolar and nonreactive organics having boiling points in the range -15° to +120°C. Compounds for which this method has been documented are:

- Vinyl Chloride
- Acrylonitrile
- Vinylidene Chloride
- Methylene Chloride
- Allyl Chloride
- Chloroform
- 1,2-Dichloroethane
- 1,1,1-Trichloroethane
- Benzene
- Carbon Tetrachloride
- Toluene

Method TO-3 is used to collect certain highly volatile organics compounds having boiling points in the range -10°C to 200°C. This method differs from both TO-1 and TO-2 because the sample is preconcentrated onto a cryogenic trap instead of a solid absorbent material. Analysis consists of flash evaporizing the preconcentrated sample from the trap onto a capillary column for subsequent GC detection. Compounds that have been successfully recovered by this method are:

- Vinylidene Chloride
- Chloroform
- 1,2-Dichloroethane
- Methylchloroform
- Benzene
- Trichloroethylene
- Tetrachloroethane
- Chlorobenzene

This method may be used in conjunction with a whole air sample (e.g., evacuated canister, Tedlar bag, etc.) provided the compounds are validated.

Method TO-4 is used for collection and analysis of a variety of organochlorine and pesticides and polychlorinated biphenyls (PCBs) in ambient air on polyurethane foam (PUF). Generally, detection limits of >1 ng/m^3 are achievable. Specific compounds for which this method have been employed are:

- Aldrin
- 4-4'-DDE
- 4,4'-DDT

- Chlordane
- Chlorobiphenyls
    - 4,4'-Di-
    - 2,4,5-Tri-
    - 2,4'5-Tri
    - 2,2',5,5'-Tetra-
    - 2,2',4,5,5'-Penta
    - 2,2',4,4',5,5'-Hexa-

Method TO-5 is used for collection and analysis of ambient air samples for individual aldehydes and ketones, such as:

- Formaldehyde
- Acetaldehyde
- Acrolein
- Propanal
- Acetone
- Crotonaldehyde
- Isobutraldehyde
- Methyl Ethyl Ketone
- Benzaldehyde
- Pentanal
- o,m,p-Tolualdehyde
- Hexanal

This method involves drawing a sample through a midget impinger containing 10 milliliters (ml) of 2,4-dinitrophenylhydrazine (DNPH reagent) and 10 ml of isoctane.

Method TO-6 is used for the determination of phosgene in ambient air. Phosgene is collected by passage of air through a solution of aniline, forming carbonilide which is then analyzed by HPLC.

Method TO-7 is used to determine N-nitrosodimethylamine (NDMA) in ambient air. The method employs GC/MS analysis of a Thermosorb/N adsorbent cartridge.

Method TO-8 is used to determine phenol and cresols in ambient air by drawing the air sample through impingers containing 15 ml of 0.1 NaOH. Impinger solution analysis is by reverse phase

HPLC, with solution of the detector dependent upon the capabilities and/or requirements of the individual user. Ultraviolet (UV) absorption, electrochemical, and fluorescence detectors have been used, but best results on relatively clean samples are obtained with UV.

Method TO-9 is used to determine Polychlorinated Dibenzo-p-Dioxins (PCDDs) in ambient air using high resolution gas chromatography/high resolution mass spectrometry (HRGC/HRMS). This method uses an inlet filter followed by cartridge (filled with PUF) and analysis by HRGC/HRMS. The following compounds have been evaluated in the laboratory using this method:

1,2,3,4-TCDD
1,2,3,4,7,8-H_xCDD
OCDD
2,3,7,8-TCDD

Method TO-10 is used for the determination of pesticides in ambient air and is based on a low volume PUF sampler. The following compounds are analyzed by GC/ECD:

Aldrin
Aroclor 1242
Aroclor 1254
Aroclor 1260
BHC
Captan
Chlorothalonil
Chlorpyrifos
2,4,-D Esters
p,p'-DDT
p,p-DDE
Dieldrin

Heptachlor
Heptachlor epoxide
Hexachlorobenzene
Hexachlorocyclopentadiene
Lindane
Methoxychlor
Mirex
trans-Nonachlor
Oxychlordane
Pentachlorphenol
Pentachlorobenzene
Ronnel

Dichlorvos
Dicofol
Endrin
Endrin Aldehyde
Folpet
1,2,3,4-Tetrachlorobenzene
1,2,3-Trichlorobenzene
2,4,5-Trichlorophenol

Method TO-11 is used for the determination of formaldehyde in ambient air. Samples can be collected using solid adsorbent followed by HPLC detection. The method modifies the sampling procedures outlined in Method TO-5 by introducing a coated adsorbent for sampling formaldehyde.

Method TO-12 combines the same type of cryogenic concentration technique used in TO-1 for high sensitivity with the FID of the GC for total non-methane organic compounds (NMOC). The method may be used for analysis of integrated samples collected in specially treated stainless steel canisters.

Method TO-13 is used for the determination of polycyclic aromatic hydrocarbons (PAHs) in ambient air. Sampling and analysis involves a combination quartz filter/adsorbent cartridge with subsequent analysis by GC/MS or GC/HPLC detection. This method covers the determination of benzo(a)pyrene specifically but enables the qualitative and quantitative analysis of other PAHs, such as:

Acenaphthene
Acenaphthylene
Anthracene
Benzo(a)anthracene
Benzo(a)pyrene
Benzo(b)fluoranthene
Benzo(e)pyrene
Benzo(g,h,i)perylene
Benzo(k)fluoranthene
Chrysene
Dibenzo(a,h)anthracene
Fluoranthene
Fluorene
Indeno(1,2,3-cd)pyrene
Naphthalene
Phenanthrene
Pyrene

Method TO-14 is used for the determination of volatile organic compounds (VOCs) in ambient air using SUMMA passivated canisters. The method is based on collection of whole air samples in 6-liter canisters. The SUMMA process chemically "polishes" the canister interior and creates a very smooth, nonreactive chromium/nickel oxide surface. The VOCs are subsequently analyzed by multidetector techniques. This method is applicable only to VOCs that have been tested and determined to be stable when stored in pressurized and subatmospheric pressure canisters. Numerous compounds, many of which are chlorinated VOCs, have been successfully tested for storage stability in pressurized canisters. The organic compounds that have been successfully collected in pressurized canisters by this method are:

Freon
Methyl chloride
Freon 114
Vinyl chloride
Methyl bromide
Ethyl chloride
Freon 11
Vinylidene chloride
Dichloromethane
Freon 113
1,1-Dichloroethane
cis-1,2-Dichloroethylene
Chloroform
1,2-Dichloroethane
Methyl chloroform
Benzene
Carbon tetrachloride
1,2-Dichloropropane
Trichloroethylene
cis-1,3-Dichloropropene
trans-1,3-Dichloropropene
1,1,2-Trichloroethane
Toluene
1,2-Dibromoethane
Tetrachloroethylene
Chlorobenzene
Ethylbenzene
m-Xylene
p-Xylene
Styrene
1,1,2,2-Tetrachloroethane
o-Xylene
1,3,5-Trimethylbenzene
1,2,4-Trimehtylbenzene
m-Dichlorobenzene
Benzyl chloride
o-Dichlorobenzene
p-Dichlorobenzene
1,2,4-Trichlorobenzene
Hexachlorobutadiene

Inorganic compounds such as total suspended particulate matter (TSP) are typically collected on filters as per the Standard Reference Methods for TSP (EPS, 1973). Analysis can be by inductively coupled argon plasma (ICP) or other recognized analytical techniques. Inorganic compounds for which this method is applicable are:

- Aluminum
- Arsenic
- Beryllium
- Cadmium
- Calcium
- Chromium
- Cobalt
- Copper
- Iron
- Lead
- Lithium
- Magnesium
- Molybdenum
- Nickel
- Phosphorus
- Platinum
- Selenium
- Silver
- Sodium
- Tellurium
- Thallium
- Tin
- Titanium
- Tungsten
- Vanadium
- Yttrium
- Zinc
- Zirconium

5.7 Continuous Analyzers

Analyzing organic air components with field portable gas chromatography equipment is another viable approach.

Field portable GC methods are available to provide real time screening data for a large number of samples. The methods are restricted to samples which are in the gaseous phase and require little or no sample preparation. The detection limits are comparable to laboratory methods for many constituents. The major disadvantage of field portable GC methods is that only screening quality data can be generated without excessive system operation and maintenance activity.

The use of laboratory GCs in a controlled environment increases the probability of successful analysis and is becoming more widely used. Laboratory GCs offer better method flexibility and performance. They are able to analyze both gaseous or liquid phase samples and can be mounted with a variety of detectors for a wide range of compound selectivity. Coupled with sample preparation techniques the quality of data generated is typically higher than with portable GCs.

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Table 5.1
COMMON GC DETECTORS

Detector	Compounds Detected	Advantages	Limitations
Flame Ionization (FID)	Organics	Response relatively constant from compound to compound.	Not as sensitive as many other detectors.
Photoionization (PID)	Most organics except methane	Response selectivity can be varied by choice of lamp energy.	Response varies from compound to compound. Less rugged than FID.
Electron Capture (ECD)	Polyhalogenated and nitro compounds	Highly sensitive and selective.	Subject to contamination. Response varies widely from compound to compound. Response drifts during temperature programming.
Alkali Flame (NPD or AFD)	Nitrogen and phosphorus compounds	Highly sensitive and selective.	Subject to contamination. Response varies more from day to day than for FID or ECD.[1]
Flame Photometric Detector (FPD)	Sulphur or phosphorus compounds (separately)	Highly selective.	Response varies from day to day. Not as sensitive as NPD for phosphorus compounds.
Hall Electrolytic Conductivity (HECD)	Halogen, sulphur, or nitrogen compounds (separately).	Highly selective. Response relatively constant from compound to compound. Stable baseline during temperature programming.	Only halogen mode has been employed extensively. Requires considerable operator attention. Not as sensitive as ECD for polyhalogenated compounds (e.g., PCBs).
Thermal Energy Analyser (TEA)	Nitrosamines	Highly sensitive and	Very expensive.

Table 5.1, cont'd.

Note:

1 The Alkali Flame detector is subject to greater drift than FID and ECD detectors for a variety of reasons. This detector operates on a surface reaction principal. Changes to the surface itself, or surface reactions, due to sample contaminants or interferents such as moisture, solvents, etc. will result in changes in instrument performance. This is an example of the importance of proper consideration of sample characteristics and desired method performance in analytical method selection.

Table 5.2

USEFUL DUAL GC DETECTOR COMBINATIONS

Detector Combination	Application
ECD-PID (Series)	Volatile Aromatics and Chlorinated Solvents
PID-FID (Series	Aromatic Hydrocarbons
ECD-FID (Series)	Chlorinated Hydrocarbons
PID-HECD (Series)	Aromatic and Halogenated Volatile Compounds
NPD-FID (Parallel)	Nitrogen or Phosphorus Compounds
FPD-FID (Parallel)	Sulphur Compounds
PID-NPD (Series)	Amines
HECD-FID (Parallel)	Hydrocarbons and Halogenated Hydrocarbons

6.0 INDUSTRY SECTORS

6.1 Sectors

The sectors to be evaluated in this study were selected by the MOE and are listed below.

- open pit mining
- food industry
- pulp and paper and allied products
- iron and steel industry
- foundries
- non-ferrous smelters and refineries
- automotive industry
- inorganic chemical manufacturing
- petroleum refineries
- asphalt paving
- petrochemical products manufacturing
- electrical power generation
- waste disposal facilities
- municipal incinerators

6.2 SIC Categories, Processes and Methodology

The fourteen sectors listed above were segregated first into four digit Standard Industrial Classification (SIC) categories, and these were further separated into individual processes. Based on discussions with the MOE, 60 SIC categories covering 153 processes were initially considered. For some of the SIC categories, information was not available because those processes did not exist in Ontario. Information was obtained on 54 SIC categories covering 148 processes. Further combining of SIC categories occurred primarily because of the similarity of some processes, with the result that the report addresses the monitoring requirements of 43 four-digit SIC categories covering 136 processes. Table 6.0 lists the sectors, SIC categories and component processes for which information was obtained.

Methodology

The "Abatement Study" which was carried out in parallel with this assignment collected quantitative data on the following items:

- Ontario industrial, commercial and municipal processes falling within the SIC categories identified above.
- Production and capacity by process
- Employment by process
- Process emissions and emission factors
- Existing emission controls and controls required to reduce air emissions to levels indicated in the proposed revisions to Reg. 308
- Capital and operating costs of control for existing and proposed equipment indicated in the proposed revisions.

The reader should note that MISA data was reviewed at the outset of the Abatement Study as a potential data source on employees and plants in the different industry sectors. This data source did not prove to be appropriate for the purposes of the Abatement Study however, and as a result data was compiled from other sources icluding Statistics Canada Files, industrial directories, association lists and through discussions with various officials.

This study relies on the industry sector emissions data and employment and plant data set out in the Abatement Study.

In the latter, process emission factors were obtained directly or calculated from information in the literature.

Monitoring equipment that would satisfy existing and alternative abatement levels was determined based on in-house experience and through discussions with Entropy Inc. The costs assocated with this equipment were also determined in the same manner.

6.3 Industry Characteristics and Emissions

In this section the contaminant emissions by process are described for each industry sector listed in Section 6.1.

6.3.1 Open Pit Mining Industry

There are four open pit gold mines (SIC 0611) and two open pit iron ore mine (SIC 0617) in Ontario. The main air emission from these mines is particulate matter generated by mining operations and transportation of ores and overburden. The emissions generated are presented in Table 6.1.

6.3.2 Food Industry

Air emissions from Ontario's Food Industry take into account both producers of food such as meat, poultry and dairy products as well as restaurants. Five food producing industries and three restaurant categories were examined in this study.

The Meat and Meat Products Industry (SIC 1011) includes 117 plants. The main emissions generated are odours, VOCs and particulates. Odours are emitted from slaughterhouses, rendering plants and processing plants while the major source of particulate emissions are smoke houses.

The Poultry Products Industry (SIC 1012) produces similar emissions to the Meat Products Industry. There are 32 plants.

The Commercial Fish Products Industry (SIC 1021) is a small part of Ontario's Food Industry. There are 17 plants. The vast amount of the commercial fish is filleted and flash frozen for export. The major source of air emissions is uncontrolled particulates released when fish is smoked.

Ninety-four plants comprise the Other Dairy Products Industry (SIC 1049). The industry produces many products, but not all of the processes used produce air emissions. The major contributors to air emissions are the whey produced as a by-product of cheese and butter production; particulates from the production of skim milk powder; and water vapour, which can create icing problems and impaired visibility, created when evaporated milk is made.

The second group within the food industry is the Restaurants (SIC 9211, 9212, 9213). It is estimated the province contains 15,000 restaurants and fast food outlets. These three SIC categories can be considered jointly because they all emit the same contaminant, odours. Some particulate fume is discharged from charcoal broiling.

Industry emissions are presented in Table 6.2.

6.3.3 Pulp and Paper and Allied Products

The Ontario Pulp and Paper and Allied Products Industry consists of two distinct groups. The first group produces pulp, kraft paper, newsprint and paperboard. The second group produces different kinds of offset printed matter and provides related services, such as type setting, plate making and binding.

There are nine Kraft Pulp Mills (SIC 2711). The major sources of air emissions in these establishments are recovery boilers and lime kilns which emit particulate matter and carbon monoxide.

Chlorine and chlorine dioxide are emitted by bleach plants.

There are 11 plants in the category of Newspaper Mills (SIC 2712). They emit particulates, acid gases and some carbon monoxide. The Kraft mill components also emit chlorine and chlorine dioxide.

The third part of the pulp and paper group of industries are the Paperboard Mills (SIC 2713). There are three types of paperboard mills. The first, with kraft pulping, has two plants. As with previous kraft pulping mills, the recovery boiler and the lime kiln are the major sources of carbon monoxide and particulate matter emitted to the air; chlorine compounds are emitted from the bleach plant.

The second type of paperboard mill of which there is only one in Ontario uses semi-chemical pulping. The main emission is uncontrolled particulate matter from its steam boiler.

The final type of paperboard mill has 13 plants. The major sources of air emissions are the steam boilers which emit uncontrolled particulate matter.

The second group of industries to be discussed in this sector produces offset printing. The major emissions from them are VOCs.

The Business Forms Industry (SIC 2811) consists of 44 plants. The industry emits uncontrolled VOCs into the air.

There are 358 plants in the Other Commercial Printing Industry (SIC 2819). Air emissions from this industry are not controlled.

The Plate Making, Type Setting and Binding Industry (SIC 2821) consists of 130 plants.

The Magazine and Newspaper Industry (SIC 2841) has 82 plants. Half of the firms emit uncontrolled VOCs.

The Other Combined Publishing, Printing Industry (SIC 2849) has 11 plants, ten of which emit uncontrolled VOCs.

Details on emissions are provided in Table 6.3.

6.3.4 Iron and Steel Industry

The Ontario Iron and Steel Industry sector has 34 plants and is made up of three parts. The first part, Ferroalloy (SIC 2911), produces special alloys that are added to steel to improve its strength and durability. This sector is small and uses exothermic ovens which produce negligible air emissions.

The second part, Steel Foundries (SIC 2912), first produces iron and then steel by manufacturing and then mixing coke with iron ore in open hearth furnaces. The steel is made in basic oxygen furnaces and formed or cast into slabs, or ingots. The major air emissions that are produced and controlled are particulates.

The third part, Other Primary Steel (SIC 2919), produces speciality and other steels and includes electric arc furnaces. Scarfing, cooling pits, forming operations and boiler emissions are included in this category.

The characteristic emissions produced are provided in Table 6.4.

6.3.5 Foundry Industries

The Ontario foundry sector encompasses 147 plants. The industry is divided into three SIC categories; namely, Iron Foundries (SIC 2941), Copper and Brass Works (SIC 2971) and Rolled Casting (SIC 2999). The process used by each is similar. Metal is melted and poured into molds (casted) and manipulated by mechanical means into a desired shape.

Particulate matter is the primary air emission in the melting, pouring, casting and cleaning processes. The casting process includes making and baking sand and other materials into molds. When the cooled casting is removed from the mold, the old material is recycled and some emissions are created. The casting and formed products are finished by grinding and machining, operations that produce low emissions. VOC emissions are released from painting of finished castings. The emissions are described in Table 6.5.

6.3.6 Non-Ferrous Smelters and Refiners

Sixteen plants make up Ontario's Non-Ferrous Smelters and Secondary Refineries Industry (SIC 2959). The study considered two segments of the industry, non-ferrous raw ore processors and non-ferrous metal recyclers. The raw ore processors mine ores which are converted into metal using combinations of mechanical, chemical or electrolytic steps. It is these conversion steps that release contaminants into the atmosphere. The main contaminants are particulate matter, which includes metals such as iron, copper and nickel, and gases. The recycling industry releases particulate matter which contains heavy metals such as lead.

The gases from specific primary smelters are covered by separate regulations: for INCO - O. Reg. 660/85 Inco Sudbury Smelter Complex - 1994 and for Falconbridge - O. Reg. 661/85 Falconbridge Smelter Complex - 1994. Thus, gases from primary non-ferrous smelters were not included in this study.

Industry emissions are set out in Table 6.6.

6.3.7 The Automotive Industries

This study considered the industrial processes that are the main sources of air emissions from Ontario's Automobile Industries The major emissions are: VOCs from the painting operations in the industry (SIC 3231); particulates generated in the production of steering and suspension parts (SIC 3254); asbestos from brake linings (SIC 3255); particulates from aluminum wheel production (SIC 3255); and lead emitted when wet cell automotive batteries are manufactured (SIC 3259).

Emissions from SIC category 3244 covering truck and bus bodies, commercial trailer bodies, non-commercial trailer bodies and mobile homes were included in SIC 3231. Emissions from motor vehicle engines and engine parts manufacturing (SIC 3251) were included with foundry emissions (SIC 2941) since these manufacturing processes are often carried out at the large automotive foundries.

Industry emissions are summarized in Table 6.7.

6.3.8 Inorganic Chemical Manufacturing

The Inorganic Chemical Manufacturing sector in Ontario is made up of a number of industries with a total of 200 plants. These industries were examined separately because they do not have common emissions.

The Domestic Clay Industry (SIC 3571) entails 27 plants. The industry produces baked clay products, primarily bricks, and the major air emission is particulate matter.

The Ceramic Industry is represented by the Imported Clay Industry (SIC 3512) which has 51 plants. Particulates constitute the main air emission from the industry.

The Cement Industry (SIC 3521) involves eight plants. Cement production entails the combining and transformation of dried ingredients into a variety of cements. Combustion of oil and gas in kilns produces emissions of sulphur dioxide and nitrogen oxides. Particulates are released when dry ingredients are combined or transferred.

There are 25 plants in the Abrasives Industry (SIC 3571) producing silicon carbide, aluminum oxide and zirconium alundum. The main air emissions are sulphur dioxide and particulate matter.

Lime production (SIC 3581) is carried out at nine plants. Lime ore is processed into lime using kilns. Particulate matter emissions are generated in the crushing, conveying and storing of lime powder.

The General Inorganic Chemicals Industry (SIC 3711) has 67 plants. These plants produce a range of products using a variety of chemical reactions. The major air emissions are ammonia, particulates, VOCs and hydrocarbons.

The final industry in this sector is the Chemical Fertilizer Industry (SIC 3721) which has 13 plants. The industry mixes dry chemicals together to produce fertilizers and in the process releases emissions of chemical particulate matter. These emissions are usually controlled with a combination cyclone and baghouse system.

The emissions from industries in this sector are summarized in Table 6.8.

6.3.9 Petroleum Refining Industry

The petroleum refining industry in Ontario (SIC 3611) consists of seven refineries. The major pollutant, sulphur dioxide, is produced by the combustion of fuel in boilers and heaters during the refining process and from specific processes such as cracking and sulphur removal.

Industry emissions are shown in Table 6.9.

6.3.10 Asphalt Paving Industry

The Asphalt Paving Industry in Ontario (SIC 3699) is comprised of 150 plants. There are two plant types: permanent (83% of the industry) and portable (17% of the industry). The primary air emission from both types of plants is particulates; gaseous and organic emissions are also released.

Paving Industry emissions are summarized in Table 6.10.

6.3.11 Petrochemical Products

The Petrochemical Products sector in Ontario includes a large number of firms in several industries, using a variety of processes. This sector has over 1600 plants.

The Organic Chemical Industry (SIC 3712) has 37 plants that produce a range of chemicals that are used by other industries or are sold as finished products. The primary air emissions are VOCs, nitrogen oxides and particulates.

The Plastic and Synthetic Resin Industry (SIC 3731) combines organic and synthetic resins to form a variety of products. There are 80 plants. The primary air emission is styrene, a VOC.

The Paint and Varnish Industry (SIC 3751) has 98 plants. The major air emissions from paint manufacturing are VOCs released from the solvents used in paints and varnishes, and particulate matter, released when pigments are conveyed, mixed and packaged.

There are 40 plants producing primary ink (SIC 3791). The major air emission is VOCs.

The major air emission from the Solvent Based Adhesive Industry (SIC 3792) are VOCs. This industry has 43 plants.

The "Other Chemicals' (SIC 3799) category of the sector contains 155 plants. This broad grouping includes: producers of metallic additives for fuels who emit heavy metals; plasticizer producers who emit nitrogen oxides; acrylic paint pigments manufacturers who emit VOCs; and solvent reclaimers who emit VOCs.

The final part of the petrochemical products sector is the dry cleaning industry (SIC 9721) with 1,200 plants. The primary emission is solvents.

Industry emissions are summarized in Table 6.11.

6.3.12 Electric Power Generation

The study examined six fossil-fuel Ontario Hydro electric power generating stations (SIC 4911). These stations fill the need for peak electrical power and burn oil, bituminous and lignite coal. The major air emission is particulate matter. Gaseous emissions are controlled by a specific regulation, O. Reg. 281/87, Ontario Hydro, and were not included in this study.

Generating station emissions are included in Table 6.12.

6.3.13 Waste Disposal Industries

The Waste Disposal Industries (SIC 4999) include landfill sites municipal waste transfer stations and incinerators, sewage sludge incinerators, privately operated incinerators and hospital waste incinerators.

Transfer Stations

The 13 transfer stations in Ontario emit some odours into the air.

Landfill

The primary air emissions from the Province's 47 primary landfill sites are methane and reactive organic gases (ROG).

Municipal Incinerators

There are two municipal incinerators in operation; one is a semi-suspension and one is a multi-chamber incinerator. The main emissions from semi-suspension incinerators are acid gases, particulate matter, heavy metals and organic compounds. Primary air emissions from multi-chamber incinerators are particulates, heavy metals, organics and acid gases.

Sewage Sludge Incinerator

There are three fluidized bed and two multi-hearth sludge incinerators in Ontario. The emissions include particulates, heavy metals, hydrocarbons, acid gases and organics.

Commercial and Industrial Incinerators

Three commercial and industrial incinerators were examined in this study. These incinerators burn rubbish that is generated on their premises and other selected waste. All three generate gaseous and particulate air emissions.

Hospital Waste Incineration

The 100 hospital incinerators in Ontario burn hazardous materials that would not be accepted at other disposal sites.

Waste disposal and incineration emissions are summarized in Table 6.13.

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Table 6.0

SIC CATEGORIES AND PROCESSES CONSIDERED

	S.I.C.	Information obtained on the following number of processes	Information reported on the following number of processes
	Open Pit Mining		
1	0611	1	1
2	0612	n/a	n/a
3	0613	n/a	n/a
4	0614	n/a	n/a
5	0616	n/a	n/a
6	0617	1	1
	Food & Rendering		
7	1011	3	3
8	1012	3	3
9	1021	1	1
10	1041	1	neg.
11	1049	1	1
12	9211	1	(as 9212)
13	9212	1	1
14	9213	1	(as 9212)
	Pulp & Paper		
15	2711	5	5
16	2712	10	10
17	2713	7	7
18	2811	1	1
19	2819	1	1
20	2821	1	1
21	2841	1	neg.
22	2849	2	2
	Iron & Steel		
23	2911	1	1
24	2912	14	14
25	2919	3	2
	Foundries		
26	2941	1	1
27	2971	1	1
28	2999	2	2
	Non-Ferrous Smelters		
29	2959	2	2
	Automotive Industry		
30	3231	1	1
31	3241	1	-
32	3242	1	-
33	3243	(as 3231)	(as 3231)
34	3244	(as 3231)	(as 3231)
35	3251	1	(as 2941)
36	3252	1	neg.
37	3253	1	(as 3231)
38	3254	1	1
39	3255	1	
40	3256	1	neg.
41	3257	1	neg.
42	3259	1	1
	Inorganic Chemicals		
43	3511	5	5
44	3512	2	2
45	3521	7	7
46	3571	2	2
47	3581	6	6
48	3711	9	9
49	3721	1	1
	Petroleum Refining Industry		
50	3611	6	6
	Ashphalt Paving Industry		
51	3699	2	2
	Petrochemical Products		
52	3712	6	6
53	3731	1	1
54	3751	2	2
55	3791	1	1
56	3792	1	1
57	3799	4	4
58	9721	2	2
	Electric Power Generation		
59	4911	3	3
	Waste Disposal Industry		
60	4999	10	10

Note:

If information obtained showed that emissions were negligible, then those processes were not reported.

Table 6.1

OPEN PIT MINING
EMISSION GENERATION

SIC	Mine Type	Particulate Emissions per Year at Rated Capacity (tonnes)
0611	Gold	4,418
0617	Iron	2,857

Table 6.2

THE FOOD INDUSTRY
EMISSION GENERATION

SIC Code & Manufacturing Processes	Emission		
	Organic Particulates (tonnes)	VOCs (tonnes)	Odour Units (ou/min/facility)
1011 - Meat & Meat Products			
Slaughterhouses			14.3×10^9
Rendering			14.3×10^9
Processing	5.25	6.3	
1012 - Poultry & Poultry Products			
Slaughterhouses			
Rendering			1.7×10^9
Processing	1.2	1.4	
1021 - Fish Products Processing	.1	.1	
1049 - Other Dairy			
Cheese	19.6		
Skim Milk Powder	.06		
Evaporated Milk	448 (water vapour)		
9211, 9212, 9213 Restaurants			5.8×10^9

Table 6.3

PULP AND PAPER AND ALLIED PRODUCTS
EMISSION GENERATION

SIC Code & Manufacturing Processes	Annual Emissions at Rated Capacity (tonnes)						
	PM	SO_2	NO_x	CO	Cl_2	ClO_2	VOC's
2711 - Kraft Pulp Mills							
. Recovery Boiler	5,097	3,227	747	1,088	0	0	
. Lime Kiln	1,538	85	590	3,638	0	0	
. Smelt Dissolving Tank	171	27	0	0	0	0	
. Steam Boilers	87	6,391	1,532	1,648	0	0	
. Bleach Plant	0	0	0	0	567	189	
2712 - Newsprint Mills w/Kraft Pulp							
. Recovery Boiler	3,377	2,434	496	692	0	0	
. Lime Kiln	1,014	103	392	2,280	0	0	
. Smelt Dissolving Tank	112	34	0	0	0	0	
. Steam Boilers[1]	102	1,594	1,223	1,734	0	0	
. Bleach Plant		0	0	0	164	221	
- Newsprint Mills w/Sulphite Pulping							
. Blowpit Stack	0	230	0	0	0	0	
. Acid Plant	0	92	0	0	0	0	
. Steam Boiler	216	330	216	562	0	0	

[1] Pro-rated from PM for 2711.

Table 6.3 (Continued)

SIC Code & anufacturing Processes	PM	SO_2	NO_x	CO	Cl_2	ClO_2	VOC's
Newsprint Mills w/Groundwood Pulping							
Steam Boilers	682	2,231	355	1,378	0	0	
Newsprint Mills							
Steam Boiler	1,120	5,660	1,120	1,650	0	0	
2713 - Paperboard Mills w/Kraft Pulping							
Recovery Boiler	3,704	1,234	469	740	0	0	
Lime Kiln	1,110	37	370	2,470	0	0	
Smelt Tank	62	12	0	0	0	0	
Steam Boilers	304	91	252	493	0	0	
Bleach Plant	0	0	0	0	81	2	
Paperboard Mills w/ Semi-Chemical Pulping							
Steam Boilers	48[2]	14	44	11	0	0	
Paperboard Mills							
Steam Boilers	340	10	107	30	0	0	

[2] Based on Newsprint Mill Boilers.

Table 6.3 (Continued)

SIC Code & Manufacturing Processes	PM	SO_2	NO_x	CO	Cl_2	ClO_2	VOC's
2811 - Business Forms Industry							6,330
2819 - Other Commercial Printing Industry							3,646
2821 - Plate Making, Type Setting and Binding Industry							490
2841 - Magazines and Newspaper Industry							38,701
2849 - Other Combined Publishing Printing Industry							
. Wallpaper							0.2
. Other							3,095.0

Table 6.4

IRON AND STEEL INDUSTRY
EMISSION GENERATION

SIC Code & Manufacturing Processes	Annual Emissions at Rated Capacity (tonnes) Particulates
2911 Ferroalloy	19.0
. Exothermic	
2912 Steel Foundries	
. Coke Plants	
- Charging	623.7
- Pushing	123.1
- Quenching	764.9
- Flue Stacks	1234.4
. Blast & Open Hearth Furnace	
- Melting	547.0
- Heating	63.4
- Dekishing	53.7
- Desulphuring	153.5
- Fugitive Emissions	1069.4
. Basic Oxygen Furnace	
- Charging	1067.0
- Tapping	30.4
- Transfer	26.6
- Melting & Refining	316.0
- Fugitive Emissions	2749.0
2919 Other Primary Steel	
. Electric Arc	306.5
. Boilers Scarfing & Pits	253.7

Table 6.5

FOUNDRIES
EMISSION GENERATION

SIC Code & Manufacturing Process	Annual Emissions at Rated Capacity (tonnes)	
	Particulates	VOCs
2941 Iron Foundries	11,406	
2971 Copper and Brass Works	305	
2999 Rolled Casting		
. Copper	92	
. Aluminum	186	2.5

Table 6.6

NON-FERROUS SMELTERS & REFINERIES
EMISSION GENERATION
(SIC 2959)

Plant Type	Annual Emissions at Rated Capacity (tonnes)	
Primary Smelters	PM	15,434
	Iron	1,901
	Copper	708
	Nickel	495
	Lead	211
	Arsenic	132
	Zinc	29
Secondary Lead Smelters	PM	60
	Lead	5.9

Table 6.7

THE AUTOMOTIVE INDUSTRY
EMISSION GENERATION

SIC Code and Manufacturing Processes	Annual Emissions in Tonnes at Rated Capacity				
		Particulates			
	VOC	Lead	Asbestos	Talc	Other
3231 - automobile and light duty truck surface coating	25,730				
3254 - steering and suspension					40.9
3255 - brake lining production			.13		.29
aluminum wheel production				19	
3259 - wet cell automotive battery production		51.1			
TOTALS	25,730	51.1	.13	19	41.19

Table 6.8

THE INORGANIC CHEMICAL MANUFACTURING INDUSTRY EMISSION GENERATION

IC Code & anufacturing Processes	Annual Emissions in Tonnes at Rated Capacity									
	PM	SO_2	VOC	NO_x	CO	F	H_2S	HC	NH_3	Nitric Acid
511 - Domestic Clay Brick Manufacturing										
. Raw Materials Handling	270									
. Tunnel Kiln (gas)	13		4.7	74	32	425				
. Tunnel Kiln (gas)	2.1		0.8	16	5.3	71				
. Tunnel Kiln (oil)	103	701	5.8	186	21.2	142				
. Gas Fired Dryer	10	876								
3512 - Imported Clay										
. Ceramics	58									
	1,887									
3521 - Cement Industry										
. Wet Kiln	513.0	93,240		10,206						
. Dry Kiln	907	13,860		15,309						
. Clinker Cooler	2438									
	1625									
. Raw Feed Mills & Handling	354									
. Finish Mills	512									
. Materials Handling & Storage	284									
571 - Abrasives										
. Aluminum Oxide	541									
. Silicon Carbide	376	3,667								

Table 6.8 (Continued)

SIC Code & Manufacturing Processes	Annual Emissions in Tonnes at Rated Capacity									
	PM	SO_2	VOC	NO_x	CO	F	H_2S	HC	NH_3	Nitric Acid
3581 - Lime										
. Lime Kiln	1660									
. Product Cooling	0									
. Product Hydration	154									
. Crushing & Grinding	1500									
. Stockpiles	10.5									
. Storage	9.5									
3711 - General Inorganic Chemicals										
. Ammonia Products	684	845		136		3.4		1221	272	
. Ammonium Phosphates	87.2							4.7		
. Urea & Carbon Products	1565	236		111				1453	.022	
. Phosphoric Acid	145					3.3		38		
. Carbon Pellets	844		4846							
. Nitric Acid	136			1781				7.4		
. Ammonium Nitrate	751							113	2412	328
. Ammonium Nitrate	712							266	2450	350
. Ammonium Phosphate	83					22.2		1500	38.3	
3721 - Chemical Fertilizer	1.6									

Table 6.9

PETROLEUM REFINING
EMISSION GENERATION
(SIC 3611)

Source	Annual Emissions in Tonnes at Rated Capacity			
Type	SO_2	NO_x	PM	Hydrocarbon (VOC)
Process Combustion		6,424	2,847	93
Heaters Gas	148			
Oil	12,410			
Boilers Gas	183			
Oil	14,600			
Total	28,033			
Catalytic Cracker	9,230	1,424	1,741	
Sulphur Plant Tail Gas	5,475			
Flares, Vents and Off Gas	1,387			
Storage Tanks				1,924
Pumps & Compressors				752

Table 6.10

THE ASPHALT PAVING INDUSTRY
EMISSION GENERATION

Plant Type	Total Annual Particulate Emissions Generated by Sector at Rated Capacity (tonnes/year)
Permanent Plants	696
Portable Plants	369
	24
Total	1089

Table 6.11

THE PETROCHEMICAL PRODUCTS INDUSTRY EMISSION GENERATION

SIC Code & Manufacturing Process	Emission (tonnes/yr)						
	Particulate	SO_2	NO_x	VOC	Styrene	Lead	Perchlorethalenes
3712 Organic Chemical Industry							
PVC	145	0.6	3,842	326			
Vinyl Chloride	1442	1.1	3,684	700			
Organic Gases and Solvents	679.2		158	7,072			
Benzene	34			14			
Styrene	12			1,053			
Styrene Acryl Butadiene	2			26			
SIC 3712 Totals	2314	1.6	7,684	9,191			
3731 - Plastics and Synthetic Resins					1,307.5		
SIC 3731 Total					1,307.5		
3751 - Paint & Varnish							
Paint - Mixing Pigments and Solvents				1,104			
Packaging	24.1						
Varnish				2,265			
SIC 3751 Total	24.1			3,369			

Table 6.11 (Continued)

SIC Code & Manufacturing Process	Emission (tonnes/yr) Particulate	SO_2	NO_x	VOC	Styrene	Lead	Perchlorethalenes
3791 - Printing Ink							
Solvent - all control types				34.4			
Pigment	19.15						
Particulate	neg.						
SIC 3791 Total	19.15			34.4			
3792 - Adhesive Industries				0.4			
3799 - Other Chemicals							
Metallic Additives						52.4	
Pigment, Acrylics, Sludges	4012						
Plasticizer & Solvent Reclamation			190	9700			
SIC 3799 Total	4012		190	9700		52.4	
SIC 9721 - Dry Cleaning							
Partial Solvent Recovery							50
Closed System							0
SIC 9721 Total							50
Total Petrochemical Products Industry	6370	1.6	7874	22,708	1,308	52.4	50

Table 6.12

ELECTRIC POWER GENERATION
EMISSION GENERATION
(SIC 4911)

Station Type	Annual Particulate Emissions Generated by Plants at Rated Capacity (tonnes)
Bituminous Fired	
. Lakeview	5,130
. Lambton	6,247
. Nanticoke	7,576
Lignite Fired	
. Thunder Bay	500
. Atikokan	300
Oil Fired	
. Lennox	444
TOTAL	20,197

Table 6.13

THE WASTE DISPOSAL INDUSTRY
EMISSION GENERATION
(SIC 4999)

Waste Disposal		Emission (tonnes/yr)																
Facilities	Odour	PM	Organic Acids	NO_x	CH_4	ROG	SO_2	CO	HC	HCl	Pb	Hg	Cd	Cr	PCDD	PCDF	PCB	Adehydes
Municipal Waste Disposal																		
Transfer Stations	weak																	
Landfill																		
No Control Passive Ventilation					3,298	34												
Active Ventilation					1,843	19												
Gas Recovery & Incineration					58	.87												
Municipal Waste Incineration																		
Semi-suspension Incinerator		240.9		188			307			571	2.4	0.18	1.5	0.6	$1.2x10^{-3}$	$2.3x10^{-3}$	$1.9x10^{-1}$	
Multichamber Incinerator		357.7		102			32			43	0.03	0.01	1.1	0.06	$3.4x10^{-5}$	$5.1x10^{-5}$	0.3	
Sewage Sludge																		
Multihearth Incinerator		152.49		703.8			58.65		58.65	17.6	.9							
Fluidized Bed Incinerator		106.7		146.3			28.4		58.6	17.6	.1							
Private Waste Disposal																		
Commercial & Industrial Incineration		4.9		121.7			40.6	178.5	24.3		0.04	0.2						
Institutional Waste Disposal																		
Hospitals Waste Incineration		108.3	71.25	57.95														46.55

7.0 ALTERNATIVE ABATEMENT SCENARIOS, INDUSTRY MONITORING COSTS

This chapter presents capital and annual operating cost estimates for monitoring alternative abatement Levels 3, 2 and 1 by process within each sector. Cost estimates have been prepared for the five scenarios described in Chapter 2, and as set out in Table 2.2.

The following tables (Tables 7.1 to 7.13) set out the capital and operating costs that will result if existing industrial and municipal facilities are appropriately monitored to ensure process control systems meet the contaminant abatement levels prescribed in each of the designated scenarios. There is not a direct relationship between each individual contaminant and cost. Cost estimates are based on cost of current programs, plus an estimate of the additional requirements in a general sense.

Underlying the following estimates are the assumptions that monitoring (stack sampling) will be carried out annually for Level 1 (LAER) abatement, once every three years for Level 2 (BACT-EA) abatement, and once every 15 years for Level 3 (NSPS) abatement. Also, implicit in the figures presented in the following tables are the cost estimating procedures for stack sampling and CEMS set out in Appendices A and B of this report. Appendix C presents a sample calculation for the Foundries sector. Appendix D provides cost estimate sheets for stack sampling and continuous emission monitoring for various companies within the industrial sectors.

Scenario A reflects existing circumstances. Scenario B pertains to stringent emission requirements for all contaminant groups whereas Scenario C is associated with less stringent emission requirements. In Scenario D the contaminant groups are priorized with some groups subject to the stringent emission requirements set out in Scenario B and others, governed by the less stringent emission requirements defined in Scenario C. Scenario E sees contaminant groups controlled to the same level as Scenario B, but the rate of implementation for achieving the prescribed emission limits is phased over a longer period of time.

Table 7.1

MONITORING COSTS
OPEN PIT MINING

(Millions of 1986 $'s)

Sectors	Scenario A		Scenario B		Scenario C		Scenario D		Scenario E			
									Phase 1		Phase 2	
	Capital	Annual Operating	Capital	Annual Operating	Capital	Annual Operating	Capital	Annual Operating	Capital	Annual Operating	Capital	Annual Operating
Gold [0611]	$0.08	$0.03	$0.08	$0.10	$0.08	$0.01	$0.08	$0.03	$0.00	$0.00	$0.08	$0.03
Iron [0617]	$0.08	$0.03	$0.08	$0.10	$0.08	$0.01	$0.08	$0.03	$0.00	$0.00	$0.08	$0.03
Total	$0.16	$0.06	$0.16	$0.20	$0.16	$0.02	$0.16	$0.06	$0.00	$0.00	$0.16	$0.06

Table 7.2

MONITORING COSTS
FOOD

(Millions of 1986 $'s)

Sectors	Scenario A		Scenario B		Scenario C		Scenario D		Scenario E			
									Phase 1		Phase 2	
	Capital	Annual Operating	Capital	Annual Operating	Capital	Annual Operating	Capital	Annual Operating	Capital	Annual Operating	Capital	Annual Operating
Meat Products [1011]	$14.70	$12.00	$14.70	$12.00	$15.10	$6.90	$14.70	$12.00	$14.70	$12.00	$0.00	$12.00
Poultry Products [1012]	$4.20	$3.40	$4.20	$3.40	$4.20	$2.00	$4.20	$3.40	$4.20	$3.40	$0.00	$3.40
Fish Products [1021]	$1.00	$0.70	$1.00	$0.70	$1.00	$0.20	$1.00	$0.70	$1.00	$0.70	$0.00	$0.70
Dairy [1049]	$5.00	$2.20	$5.00	$2.20	$5.00	$1.80	$5.00	$2.20	$5.00	$2.20	$0.00	$2.20
Restaurants [9211,9212,9213]	$10.70	$1.00	$10.70	$1.00	$0.00	$0.00	$10.70	$1.00	$0.00	$0.00	$10.70	$1.00
Total	$35.60	$19.30	$35.60	$19.30	$25.30	$10.90	$35.60	$19.30	$24.90	$18.30	$10.70	$19.30

Table 7.3

MONITORING COSTS
PULP & PAPER & ALLIED PRODUCTS

(Millions of 1986 $'s)

Sectors	Scenario A		Scenario B		Scenario C		Scenario D		Scenario E			
									Phase 1		Phase 2	
	Capital	Annual Operating	Capital	Annual Operating	Capital	Annual Operating	Capital	Annual Operating	Capital	Annual Operating	Capital	Annual Operating
Kraft Pulp Mills [2711]	$9.90	$3.50	$9.90	$4.10	$9.90	$2.50	$9.90	$3.50	$5.50	$2.10	$4.40	$1.40
Newsprint/Kraft Mill [2712]	$4.50	$1.60	$4.50	$1.60	$4.50	$1.10	$4.50	$1.60	$2.50	$1.00	$2.00	$0.60
Newsprint/Sulphite [2712]	$2.10	$0.70	$2.10	$0.70	$2.10	$0.60	$2.10	$0.70	$1.00	$0.40	$1.10	$0.30
Newsprint/Groundwood [2712]	$1.70	$0.60	$1.70	$0.60	$1.70	$0.50	$1.70	$0.60	$1.10	$0.40	$0.60	$0.20
Newsprint Mills [2712]	$1.80	$1.20	$1.80	$1.20	$1.80	$0.90	$1.80	$1.20	$0.50	$0.40	$1.30	$0.80
Sub Total [2712]	$10.10	$4.10	$10.10	$4.10	$10.10	$3.10	$10.10	$4.10	$5.10	$2.20	$5.00	$1.90
Paperboard/Kraft [2713]	$3.00	$1.00	$3.00	$1.00	$3.00	$0.80	$3.00	$1.00	$2.00	$0.60	$1.00	$0.40
Paperboard/Chemical [2713]	$0.90	$0.30	$0.90	$0.30	$0.90	$0.20	$0.90	$0.30	$0.40	$0.10	$0.50	$0.20
Paperboard Mills [2713]	$6.90	$2.20	$6.90	$2.20	$6.90	$1.90	$6.90	$2.20	$2.10	$0.70	$4.80	$1.50
Sub Total [2713]	$10.80	$3.50	$10.80	$3.50	$10.80	$2.90	$10.80	$3.50	$4.50	$1.40	$6.30	$2.10
Business Forms [2811]	$0.20	$0.20	$0.20	$0.50	$0.00	$0.04	$0.20	$0.20	$0.00	$0.00	$0.20	$0.20
Other Com Printing [2819]	$1.50	$1.30	$1.70	$3.80	$0.00	$0.30	$1.50	$1.30	$0.00	$0.00	$1.50	$1.30
Plate Making [2821]	$0.60	$0.50	$0.60	$1.50	$0.00	$0.10	$0.60	$0.50	$0.00	$0.00	$0.60	$0.50
Magazines & Newspape [2841]	$0.80	$0.40	$0.80	$0.50	$0.00	$0.10	$0.80	$0.40	$0.00	$0.00	$0.80	$0.40
Other Combined P&P [2849]	$0.10	$0.04	$0.10	$0.10	$0.00	$0.01	$0.10	$0.04	$0.00	$0.00	$0.10	$0.04
Total	$34.00	$13.54	$34.20	$18.10	$30.80	$9.05	$34.00	$13.54	$15.10	$5.70	$18.90	$7.84

Table 7.4

MONITORING COSTS
IRON & STEEL

(Millions of 1986 $'s)

Sectors	Scenario A		Scenario B		Scenario C		Scenario D		Scenario E			
									Phase 1		Phase 2	
	Capital	Annual Operating	Capital	Annual Operating	Capital	Annual Operating	Capital	Annual Operating	Capital	Annual Operating	Capital	Annual Operating
Ferro-alloy [2911]	$0.07	$0.02	$0.07	$0.02	$0.07	$0.02	$0.07	$0.02	$0.07	$0.02	$0.00	$0.02
Steel Foundries [2912]	$21.70	$8.70	$21.70	$8.70	$21.70	$7.00	$21.70	$8.70	$17.10	$6.10	$4.60	$8.70
Other Primary Steel [2919]	$17.60	$4.30	$17.60	$4.30	$17.60	$2.30	$17.60	$4.30	$17.60	$4.30	$0.00	$4.30
Total	$39.37	$13.02	$39.37	$13.02	$39.37	$9.32	$39.37	$13.02	$34.77	$10.42	$4.60	$13.02

Table 7.5

MONITORING COSTS FOUNDRIES

(Millions of 1986 $'s)

Sectors	Scenario A		Scenario B		Scenario C		Scenario D		Scenario E			
									Phase 1		Phase 2	
	Capital	Annual Operating	Capital	Annual Operating	Capital	Annual Operating	Capital	Annual Operating	Capital	Annual Operating	Capital	Annual Operating
Iron [2941]	$17.10	$8.90	$17.10	$8.90	$17.10	$5.80	$17.10	$8.90	$12.00	$5.00	$5.10	$8.90
Copper & Brass [2971]	$4.80	$2.20	$5.00	$2.20	$4.80	$1.60	$4.80	$2.20	$3.40	$1.50	$1.40	$2.20
Rolled Casting [2999]	$10.30	$5.60	$10.30	$5.60	$10.30	$4.20	$10.30	$5.60	$7.20	$3.90	$3.10	$5.60
Total	$32.20	$16.70	$32.40	$16.70	$32.20	$11.60	$32.20	$16.70	$22.60	$10.40	$9.60	$16.70

Table 7.6

MONITORING COSTS NON-FERROUS SMELTERS

(Millions of 1986 $'s)

Sectors	Scenario A		Scenario B		Scenario C		Scenario D		Scenario E			
									Phase 1		Phase 2	
	Capital	Annual Operating	Capital	Annual Operating	Capital	Annual Operating	Capital	Annual Operating	Capital	Annual Operating	Capital	Annual Operating
Primary Smelters [2959]	$42.80	$20.40	$42.80	$20.40	$42.80	$15.20	$42.80	$20.40	$38.50	$18.40	$4.30	$20.40
Lead Smelters [2959]	$17.20	$8.10	$17.20	$8.10	$17.20	$6.10	$17.20	$8.10	$15.50	$7.30	$1.70	$8.10
Total	$60.00	$28.50	$60.00	$28.50	$60.00	$21.30	$60.00	$28.50	$54.00	$25.70	$6.00	$28.50

Table 7.7

MONITORING COSTS AUTOMOTIVE

(Millions of 1986 $'s)

Sectors	Scenario A		Scenario B		Scenario C		Scenario D		Scenario E			
									Phase 1		Phase 2	
	Capital	Annual Operating	Capital	Annual Operating	Capital	Annual Operating	Capital	Annual Operating	Capital	Annual Operating	Capital	Annual Operating
Auto Surface Coating [3231]	$2.00	$1.30	$1.90	$4.00	$2.00	$0.30	$2.00	$1.30	$0.00	$0.00	$2.00	$1.30
Steering & Suspensio [3254]	$2.90	$1.00	$2.90	$1.30	$0.00	$0.03	$2.90	$1.00	$0.00	$0.00	$2.90	$1.00
Brake Lining [3255]	$0.30	$0.20	$0.30	$0.20	$0.30	$0.10	$0.30	$0.20	$0.00	$0.00	$0.30	$0.20
Aluminium Wheel [3255]	$0.10	$0.01	$0.01	$0.02	$0.00	$.00	$0.10	$0.01	$0.00	$0.00	$0.10	$0.01
Wet Cell Auto Batter [3259]	$5.60	$2.70	$5.60	$2.70	$5.60	$2.00	$5.60	$2.70	$5.60	$2.70	$0.00	$2.70
Total	$10.90	$5.21	$ 10.71	$8.22	$7.90	$2.43	$ 10.90	$5.21	$5.60	$2.70	$5.30	$5.21

Table 7.8

MONITORING COSTS
INORGANIC CHEMICAL MANUFACTURING

(Millions of 1986 $'s)

Sectors	Scenario A		Scenario B		Scenario C		Scenario D		Scenario E			
									Phase 1		Phase 2	
	Capital	Annual Operating	Capital	Annual Operating	Capital	Annual Operating	Capital	Annual Operating	Capital	Annual Operating	Capital	Annual Operating
Domestic Clay [3511]	13.8	5.2	13.8	5.2	3.8	4	13.8	5.2	13.8	5.2	0	5.2
Imported Clay [3512]	$2.80	$1.20	$2.80	$1.20	$2.80	$1.00	$2.80	$1.20	$2.80	$1.20	$0.00	$1.20
Cement [3521]	$5.60	$2.50	$5.60	$2.50	$5.60	$2.00	$5.60	$2.50	$4.10	$2.30	$1.50	$2.30
Abrassives [3571]	$34.90	$14.30	$34.90	$14.30	$34.90	$9.00	$34.90	$14.30	$31.40	$12.90	$3.50	$14.30
Lime [3581]	$3.00	$1.20	$3.00	$1.20	$3.00	$0.90	$3.00	$1.20	$2.00	$0.80	$1.00	$1.20
General Inorganic [3711]	$72.00	$23.90	$72.00	$23.90	$72.00	$30.00	$72.00	$23.90	$50.40	$16.70	$21.60	$23.90
Fertilizer [3721]	$8.40	$4.60	$8.40	$4.60	$8.40	$3.00	$8.40	$4.60	$8.40	$4.60	$0.00	$4.60
Total	$140.50	$52.90	$140.50	$52.90	$130.50	$49.90	$ 140.50	$52.90	$ 112.90	$43.70	$27.60	$52.70

Table 7.9

MONITORING COSTS
PETROLEUM REFINERIES

(Millions of 1986 $'s)

Sectors	Scenario A		Scenario B		Scenario C		Scenario D		Scenario E			
									Phase 1		Phase 2	
	Capital	Annual Operating	Capital	Annual Operating	Capital	Annual Operating	Capital	Annual Operating	Capital	Annual Operating	Capital	Annual Operating
Petroleum Refinerie [3810]	$11.40	$4.30	$11.40	$4.30	$11.40	$2.30	$11.40	$4.30	$2.00	$0.60	$9.40	$4.30

Table 7.10

MONITORING COSTS
ASPHALT

(Millions of 1986 $'s)

Sectors	Scenario A		Scenario B		Scenario C		Scenario D		Scenario E			
									Phase 1		Phase 2	
	Capital	Annual Operating	Capital	Annual Operating	Capital	Annual Operating	Capital	Annual Operating	Capital	Annual Operating	Capital	Annual Operating
Asphalt [3699]	$8.20	$3.20	$8.20	$3.20	$8.20	$2.60	$8.20	$3.20	$8.20	$3.20	$0.00	$3.20

Table 7.11

MONITORING COSTS
PETRO-CHEMICAL PRODUCTS

(Millions of 1986 $'s)

Sectors	Scenario A		Scenario B		Scenario C		Scenario D		Scenario E			
									Phase 1		Phase 2	
	Capital	Annual Operating	Capital	Annual Operating	Capital	Annual Operating	Capital	Annual Operating	Capital	Annual Operating	Capital	Annual Operating
Organic Chemical [3712]	$9.40	$12.30	$9.40	$12.30	$9.40	$6.00	$9.40	$12.30	$6.00	$4.60	$3.40	$12.30
Plastics & Synthetic Resins [3731]	$0.80	$0.60	$0.80	$1.70	$0.80	$0.10	$0.80	$0.60	$0.00	$0.00	$0.80	$0.60
Paint & Varnish [3751]	$1.10	$0.70	$1.10	$0.70	$0.00	$0.20	$1.10	$0.70	$1.10	$0.70	$0.00	$0.70
Printing Ink [3791]	$2.20	$1.00	$2.20	$1.80	$2.20	$1.00	$2.20	$1.00	$2.20	$0.50	$0.00	$1.00
Adhesives [3792]	$0.40	$0.20	$0.40	$0.90	$0.40	$0.02	$0.40	$0.20	$0.00	$0.00	$0.40	$0.20
Other Chemicals [3799]	$38.50	$50.50	$38.50	$50.50	$38.50	$24.40	$38.50	$50.50	$23.00	$30.00	$15.50	$50.50
Dry Cleaning [9721]	$5.90	$2.20	$5.90	$6.70	$5.90	$0.50	$5.90	$2.20	$0.00	$0.00	$5.90	$2.20
Total	$58.30	$67.50	$58.30	$74.60	$57.20	$32.22	$58.30	$67.50	$32.30	$35.80	$20.00	$67.50

Table 7.12

MONITORING COSTS POWER GENERATION

(Millions of 1986 $'s)

Sectors	Scenario A		Scenario B		Scenario C		Scenario D		Scenario E			
									Phase 1		Phase 2	
	Capital	Annual Operating	Capital	Annual Operating	Capital	Annual Operating	Capital	Annual Operating	Capital	Annual Operating	Capital	Annual Operating
Power Generation [4911]	3.5	0.9	3.5	1.9	0	0.1	3.5	0.9	0	0	3.5	0.9

Table 7.13

MONITORING COSTS
WASTE DISPOSAL

(Millions of 1986 $'s)

Sectors	Scenario A		Scenario B		Scenario C		Scenario D		Scenario E			
									Phase I		Phase 2	
	Capital	Annual Operating	Capital	Annual Operating	Capital	Annual Operating	Capital	Annual Operating	Capital	Annual Operating	Capital	Annual Operating
Transfer Stations [4999]	$0.70	$0.30	$0.70	$0.50	$0.00	$0.02	$0.70	$0.30	$0.70	$0.30	$0.00	$0.30
Landfill [4999]	$11.60	$1.00	$11.60	$4.00	$0.00	$0.05	$11.60	$1.00	$1.00	$0.35	$10.60	$1.00
Incinerators [4999]	$1.00	$0.40	$1.00	$0.40	$0.70	$0.30	$1.00	$0.40	$0.30	$0.10	$0.70	$0.40
Sewage Sludge Incinera [4999]	$1.30	$0.50	$1.30	$0.50	$1.30	$0.40	$1.30	$0.50	$0.30	$0.10	$1.00	$0.50
Private Incinerators [4999]	$0.90	$0.20	$0.90	$0.20	$0.90	$0.20	$0.90	$0.20	$0.30	$0.10	$0.60	$0.20
Hospital Incinerators [4999]	$29.00	$11.40	$29.00	$11.40	$29.00	$8.20	$29.00	$11.40	$8.70	$3.40	$20.30	$11.40
Total	$44.50	$13.80	$44.50	$17.00	$31.90	$9.17	$44.50	$13.80	$11.30	$4.35	$33.20	$13.80

8.0 COSTS ASSOCIATED WITH THE AUDITING AND ADMINISTRATION OF THE PROPOSED REVISIONS TO REGULATION 308

8.1 Introduction

While most of the abatement and monitoring costs of complying with Regulation 308 are borne by industrial, municipal and private sector users, certain costs are the responsibility of the Ministry of the Environment (MOE). The purpose of this chapter is to estimate these costs given the current legislation and to estimate their future level should the legislation change.

The data for much of the analysis which follows was obtained directly from MOE. Discussions were held with senior officials in the Air Resources Branch, Environmental Approval and Land Use Planning Branch, Investigations and Enforcement Branch as well as with officials from the Central and West-Central Regions. In addition to information gleaned through discussions, data was also extracted from a variety of MOE documents including operating budgets and work plans for the different branches and regions.

The steps required to make the necessary calculations and estimates are:

1. identify MOE activities currently associated with Reg. 308 as well as the branches/sections/units of MOE responsible for these activities.
2. examine the budgets of the branches/sections/units identified above and calculate the portion of these budgets currently spent on activities associated with the application of Reg. 308.
3. express current costs in unit terms (e.g., per Certificate of Approval).

4. identify and cost additional tasks to be performed by MOE should the proposed revisions to Reg. 308 be passed. Express in unit (e.g., Certificate of Approval) terms.
5. estimate current number of firms (e.g., number of Certificates of Approval) subject to existing Reg. 308.
6. for existing stock of firms, estimate cost to MOE of applying existing Reg. 308.

8.2 Definitions

Before undertaking the exercise outlined above, it is useful to clarify the terms "monitoring, auditing and administration" and show how they pertain to the MOE.

In simple terms, monitoring is the act of measuring something, in this case contaminant emission levels. The monitoring function is the responsibility of the private sector with respect to stack testing and of the MOE with respect to ambient air quality (although there is a movement towards obliging the private sector to monitor ambient air). Monitoring is usually undertaken either by the companies producing the contaminants or by consultants engaged specifically for that purpose.

Auditing is the act of ensuring that monitoring is being carried out correctly; that is, according to procedures set by MOE. As such, the auditing activity is the responsibility of MOE.

Administration costs are those costs in MOE associated with the application of Reg. 308 that are not already covered by the auditing function.

8.3 MOE Branches Active in the Application of Regulation 308

8.3.1 Branch Activities, Present and Future

The organization chart for MOE shows four divisions reporting to the offices of the Minister and Deputy Minister. They are: Environmental Services, Intergovernmental Relations & Strategic Projects, Operations and Corporate Resources. Each division is composed of a number of branches, sections and units. The branches and activities currently associated with the application of Reg. 308 are discussed in the following sections:

8.3.2 Air Resources Branch (Environmental Services Division)

The Air Resources Branch is composed of three sections (air quality and meteorology, emission technology and regulation development, phytotoxicology), and performs the following tasks: (1) compiles air quality statistics from the monitoring instruments across Ontario and prepares reports to assist regional offices in controlling emissions; (2) develops MOE's air quality criteria, standards, guidelines and regulations; and (3) conducts assessment surveys in the vicinity of industries for information about the effects of air pollution on soils and vegetation for environmental management purposes.

8.3.3 Environmental Approvals and Land Use Planning Branch: Approvals Section (Operations Division)

The Environmental Approvals Section processes applications submitted by industrial, municipal and private sectors for the establishment of (among other things) air emission control devices as required by the Environmental Protection Act. The section reviews technical designs of proposed control facilities to ensure compliance with environmental regulations, criteria and guidelines.

8.3.4 Investigations and Enforcement Branch (Operations Division)

This Branch is vested with the responsibility for all aspects of environmental enforcement within MOE. In the case of Reg. 308, this refers to the Environmental Protection Act. The Branch complements the abatement and control activities of the Operations Division through investigation and enforcement activity.

8.3.5 Regional Offices (Operations Division)

The six regional offices are:

1) Central Region (Toronto)
2) Northeastern Region (Sudbury)
3) Northwestern Region (Thunder Bay)
4) Southeastern Region (Kingston)
5) Southwestern Region (London)
6) West-Central Region (Hamilton)

They are the agents of delivery of MOE's services to municipalities, individuals and corporations. The regional offices are organized functionally into three sections; namely, Abatement, Utility Operations and Technical Support. The programs of the Abatement and Technical Support Sections to protect air quality are relevant to Reg. 308.

8.3.6 Policy and Planning Branch

In the event that a firm claims that a control order or Regulation will cause undue financial hardship, an economic or financial analysis may be required under Policy 02-02. Such analyses would be carried out or supervised by Policy and Plannng Branch.

8.4 Unit Cost of Applying Regulation 308

The unit cost to MOE of applying Reg. 308 is calculated in Table 8.1. It is composed of two parts; namely,

1) a unit cost of existing MOE activities associated with the application of Reg. 308; and
2) a multiplicative factor to cover expected additional activities required of MOE as a result of the introduction of the proposed revisions to Reg. 308.

With respect to the cost of existing activities to MOE, each of the branches and regional offices listed in Section 8.3 was asked to estimate the portion of its 1988-89 budget that was associated with the application of Reg. 308. Details of these calculations are contained in Appendix F, Table F.2 through to F.5. The totals are reported in Table 8.1. (For example, Air Resources Branch estimates that of a Branch budget of $8.6 million, $3.6 million was spent on applying Reg. 308).

At present, the four branches/offices report an expenditure of $15.0 million directly on Reg. 308. Administrative costs add $2.7 million to the direct costs to give a total present cost to MOE of applying Reg. 308 of $17.7 million.

Should the proposed revisions to Reg. 308 be implemented, several of the branches/offices will have new responsibilities in addition to the tasks of audit and administration already performed. For example, the Air Resources Branch will be obliged to categorize and prepare dossiers on the contaminants to be covered by the regulation as well as to increase modelling and monitoring activity. The Air Resources Branch estimates that for the same number of approvals to be issued, its activity will double with the implementation of the proposed revisions to Reg. 308. The costs will be twice as high as they are now. To account for this in the unit cost calculated in Table 8.1, an "additional cost factor" of 2.0 is applied to Air Resources's existing costs of $3.9 million to yield a cost to Air Resources under the revised Reg. 308 of $7.8 million before taking an increased number of Certificates of Approval into account. Likewise, additional cost factors of 1.0, 1.5 and 1.5 have been applied to Environmental Approvals, Environmental Enforcement and the Regions respectively.

The unit cost of current MOE activity on Reg. 308 is calculated based on the number of Certificates of Approval issued annually. In choosing the Certificate of Approval as the basic unit by which costs are expressed, several important assumptions have been made; namely,

1) All MOE activity associated with the application of Reg. 308 is ultimately directed towards the issuance of Certificates of Approval. Therefore, all costs can be expressed per Certificate of Approval.

2) It is acknowledged that Certificates of Approval vary enormously in size. However, it is assumed that the distribution is normal. Therefore, the unit cost per "average" Certificate of Approval accurately reflects the mean of this normal distribution.

Based on these assumptions, Environmental Approvals reports that in the recent past 1,200 Certificates of Approval have been issued annually. The approximate unit cost per average

Certificate of Approval has been $14,750. Should the proposed revisions to Reg. 308 be made, this cost will become approximately $22,400.

8.5 The Cost to MOE of Applying the Proposed Revisions to Reg. 308

For the purposes of this study, the estimated costs to MOE resulting from the implementation of the proposed revisions to Reg. 308 are based on its being applied to the existing inventory of 3,669 firms. There will no doubt be growth in this inventory in the future, but it is not within the scope of this report to address this dimension. Readers are advised to review the report by Informetrica (1989) which provides a more complete estimate of costs incurred by MOE by taking into account both existing and new industrial stock.

Given the current inventory of plants, a total cost of $81.8 million would be incurred if all existing plants were to be issued a Certificate of Approval.

According to MOE, a Certificate of Approval requires re-examination after 10 years. As a result of this provision the MOE activity associated with granting Certificates of Approval to existing industry would follow a five year cycle. After initiation there would be a five year hiatus followed by a five year period of re-examination followed by a five year hiatus and so on.

References

Informetrica Limited, 1989. "Ontario Aggregate and Sectoral Macroeconomic Impacts of Revisions to Regulation 308." Prepared for the MOE.

Table 8.1

UNIT COST CALCULATION

Item	Air Resources	Env. Approvals	Env. Enforcement	Regions	TOTAL
1. Section Direct Budget	$8.6	$8.7	$4.8	$32.7	$54.8
Program Administration Cost	$0.0	$1.3	$0.7	$4.7	$6.7
Ministry Administration Cost	$0.6	$0.6	$0.4	$2.2	$3.8
Sub-total: Total Branch Costs	$9.2	$10.5	$5.9	$39.6	$65.3
2. Section Budget Spent on Regulation 308	$3.6	$2.9	$3.0	$5.5	$15.0
Admin Costs Associated with 308	$0.3	$0.6	$0.7	$1.2	$2.7
Sub-total: Present Costs of 308	$3.9	$3.5	$3.6	$6.7	$17.7
3. Additional Activities Cost Factor	2.0	1.0	1.5	1.5	
GRAND TOTAL (1988 $ Millions)	$7.8	$3.5	$5.4	$10.2	$26.8

Average Annual Number of Certificates of Approval issued = 1,200

UNIT COST PER CERTIFICATE OF APPROVAL - EXISTING REGULATION 308 = $14,768
UNIT COST PER CERTIFICATE OF APPROVAL - PROPOSED REVISIONS TO REGULATION 308 = $22,333

Note: The additional activities cost factor is included to take into account the cost of additional responsibilities of MOE branches as a result of the introduction of proposed revisions to Reg. 308.

9.0 CONCLUSION

9.1 Introduction

This report has examined the technology requirements and capital and operating costs that would be associated with monitoring activities given proposed revisions to Regulation 308. Three levels of monitoring were evaluated in accordance with prescribed abatement limits. These in turn were applied to five scenarios.

9.2 Summary of Costs

The estimated capital and operating costs by industrial sector for existing firms for each of the five scenarios are summarized in Table 9.1. Scenarios A, B and D all have identical capital costs of $479 million. Of these scenarios, Scenario B has the highest operating cost estimated at $258 million, while both Scenarios A and D are $19 million lower at $239 million.

Scenario C has the lowest capital cost at $435 million and the lowest operating cost at $161 million.

Scenario E differs from the other scenarios in that it has a slower rate of implementation. In the first 15 years, capital costs would amount to $324 million and annual operating costs, $161 million. At the end of 20 years, a further capital expenditure of $155 million would be incurred, and annual operating costs would amount to $233 million.

For MOE the additional costs associated with the proposed revisions to Reg. 308 amount to $22,300 per Certificate of Approval.

In Scenarios A, B, C and D, all existing firms would be issued a Certificate of Approval in the first five years after the regulation is enacted. For Scenario E the phase-in period would be 20 years.

Table 9.1

SCENARIO MONITORING COSTS

(Millions of 1986 $' s)

Industrial Sectors	Scenario A Costs		Scenario B Costs		Scenario C Costs	
	Capital	Operating	Capital	Operating	Capital	Operating
Open Pit Mines	$0.16	$0.06	$0.16	$0.20	$0.16	$0.02
Food Industries	$35.60	$19.30	$35.60	$19.30	$25.31	$10.90
Pulp & Paper & Allied Industry	$34.00	$13.54	$34.20	$18.10	$30.80	$9.05
Iron & Steel	$39.37	$13.02	$39.37	$13.02	$39.37	$9.32
Foundries	$32.20	$16.70	$32.40	$16.70	$32.20	$11.60
Non-ferrous Smelters	$60.00	$28.50	$60.00	$28.50	$60.00	$21.30
Automobile Industry	$10.90	$5.21	$10.71	$8.22	$7.90	$2.43
Inorganic Chemical Industries	$140.50	$52.90	$140.50	$52.90	$130.50	$49.90
Petroleum Refineries	$11.40	$4.30	$11.40	$4.30	$11.40	$2.30
Asphalt Paving	$8.20	$3.20	$8.20	$3.20	$8.20	$2.60
Petro-chemical Industries	$58.30	$67.50	$58.30	$74.60	$57.20	$32.22
Power Generation	$3.50	$0.90	$3.50	$1.90	$0.00	$0.10
Waste Disposal	$44.50	$13.80	$44.50	$17.00	$31.90	$9.17
	$478.63	$238.93	$476.84	$257.94	$434.94	$160.91

Industrial Sectors	Scenario D Costs		Scenario E Costs Phase 1		Scenario E Costs Phase 2	
	Capital	Operating	Capital	Operating	Capital	Operating
Open Pit Mines	$0.16	$0.06	$0.00	$0.00	$0.16	$0.06
Food Industries	$35.60	$19.30	$24.90	$18.30	$10.70	$19.30
Pulp & Paper & Allied Industry	$34.00	$13.54	$15.10	$5.70	$18.90	$7.84
Iron & Steel	$39.37	$13.02	$34.77	$10.42	$4.60	$13.02
Foundries	$32.20	$20.60	$22.60	$10.40	$9.60	$16.70
Non-ferrous Smelters	$60.00	$28.50	$54.00	$25.70	$6.00	$28.50
Automobile Industry	$10.90	$5.21	$5.60	$2.70	$5.30	$5.21
Inorganic Chemical Industries	$140.50	$52.90	$112.90	$43.70	$27.60	$52.70
Petroleum Refineries	$11.40	$4.30	$2.00	$0.60	$9.40	$4.30
Asphalt Paving	$8.20	$3.20	$8.20	$3.20	$0.00	$3.20
Petro-chemical Industries	$58.30	$67.50	$32.30	$35.80	$26.00	$67.50
Power Generation	$3.50	$0.90	$0.00	$0.00	$3.50	$0.90
Waste Disposal	$44.50	$13.80	$11.30	$4.35	$33.20	$13.80
	$478.63	$242.83	$323.67	$160.87	$154.96	$233.03

APPENDIX A

Cost Model Development

APPENDIX A: COST MODEL DEVELOPMENT

A cost model capable of generating capital and operating costs for a generic CEMS was developed for this study to take into account the key features of a certifiable system. The factors used were based on professional opinion and discussions held with suppliers of equipment and systems.

The essential considerations contained in the model are:

1. Capital cost
    - instruments
    - sample extraction/conditioning system
    - data acquisition system
    - installation cost
    - special retrofit costs
    - certification cost
    - commissioning cost
2. Operating costs
    - auditing cost
    - maintenance cost
    - data processing cost

The model is appropriate for application in monitoring up to four measured parameters, plus opacity, four separate sources per installation and either in situ or extractive sampling.

A scheme of cost multiplier factors was developed for the source gas conditions in terms of temperature, corrosivity and dust loading.

A similar scheme of fractional multiplier factors was developed for the additive effects on gross costs of multisources and instruments, maintenance and other parameters.

A.1 Basic Model Parameters

For the model to work, the CEMS for each process to be evaluated needs to be defined in terms of the following:

1. the parameters to be monitored, and therefore instrumentation requirements (A.2, A.7, A.8, A.11)
2. whether the monitor is extractive or in situ (A.2, A.7-A.9)
3. the number of individual sources to be monitored at a given location (A.3, A.4, A.5, A.7-A.11)
4. the degree of difficulty of sampling based on temperature, corrosivity and dust burden of the gas (A.12)
5. special requirements for a retrofit (A.7, A.8)
6. the equipment to be used (A.5)

A.2 Instrument Requirements

The number of individual instruments required in a given situation is determined by whether the instrument is to be associated with an extractive or in situ system, and the number of sources to be monitored. Once the selections have been made, including unit costs of the instrument, a total value of the instrument package is calculated as follows.

For each extractive analysis, one analyser can be assigned from one up to four sources. For each in situ analysis, one analyser must be assigned to each source.

A.3 Sampling Condition and Extraction Systems

The basic capital cost is associated with sampling conditions and extraction systems. Once this is selected from the appropriate range, a formula then multiplies the cost by the number of sources, n, using a multiplier calculated by factor = (0.8 +

0.2 n) (i.e. when n = 1, factor = 1, and for 2 to 4 etc.) the cost increases by 20% per source to reflect valuing and other costs in the sampling system.

There is no comparable cost associated with in situ systems.

A.4 Data Acquisition System

This system represents the computer controlled zero/calibration and data recording and basic trouble shooting system. Also, included are the number averaging and documentation systems required to produce daily reports, etc.

The model has been designed to add 10% to the cost for each extra source and extractive parameter, e.g. when there are three sources and four parameters, the factor = ((3x.1)+(4x.1)+0.8) = 1.5 times the base case.

Both extractive and in situ systems incur this same cost.

A.5 Installation Cost

There is a basic cost for installation of a single system. This depends on the influence of in situ or extractive technology, and the number of sources. For each extra extractive source, the cost is increased by 30% of the base, and for each extra in situ source, by 100% of the base. Combined systems are additive in cost, e.g. for a three source system with both one extractive and one in situ monitor, the factor is:

$$= ((0.7 + 0.3 \times 3) + (1.0 \times 3))$$

$$= 4.6$$

A.6 Retrofit Costs

For special cases in which stacks are very high, difficult to get to, and require ladders and platforms etc., the model has been developed to take into account a retrofit cost.

For a single source a value is selected, based on estimates received from contractors. This is multiplied by the total number of separate sources (assuming all are equally affected) and no distinction is made between extractive and in situ monitors.

A.7 Certification Cost

Based on Appendix F to EPA Register 40-CFR-60 reference material, costs have been calculated for the requirements of the annual audit of various CEMS. For a three parameter (NO_x, SO_x, O_2) one source system the annual audit (four quarterly checks) was assessed at 219 hours at $35/hr U.S. For a four source system the value was 527 hours. From this data it was calculated that:

1. each source incrementally represented 103 hours, or about 50% the base cost of 219 hours
2. the basic costs for one source was $7,665 U.S., or about $9,600 (1988 dollars) Cdn. for three parameters
3. we assumed that each extra parameter (over one) is about 10% of the base cost, and therefore the base cost would be $9,600/1.2 or about $8,000.

The certification test requires a 200 hour document outlining a complete QA/QC strategy plus the actual reference testing. We assumed the testing would be about 50% of the audit.

Hence the certification test would cost:

$9,000 (200 hours) + 0.5 (annual audit).

The annual audit costs:

$8,000 x ((.9 + .1 m) x (.5 + .5 n))

where m is the number of parameters at each source and n is the number of sources at each site to be evaluated.

A.8 Commissioning Costs

Data supplied by the EPA and Entropy suggest that each new subpart Da and Db CEMS requires six months to bring completely on line. The activities are not full time during this period and tend to tail off towards the end. It is assumed that for a three parameter, two source system the actual commissioning costs would be about 20 days, at $1,000/day (Canadian dollars, 1988), including spare parts etc. Multipliers of 30% per parameter and 20% per source have been assumed for this situation, with both the extractive and in situ units being similar. From these considerations, the base cost of a CEMS would be 20 x 1000 (1.6 x 1.2) or about $10,000 (Canadian dollars, 1988).

No distinction has been made between opacity monitors and other instruments, although it is generally believed the opacity monitors are more reliable and quicker to commission.

A.9 Auditing Costs

As previously noted, under certification costs, auditing costs have been derived from the EPA Register 40-CFR-60, Appendix F, predictions for subpart Da and Db (mainly SO_x, NO_x and reference gas and opacity).

The model extrapolates these costs to other gases such as HCl or organics.

A.10 Maintenance Costs

These are derived from EPA information. In summary the following maintenance times have been allocated.

	Mins/day	Plus	Days/ month	Total Days/ year
1. opacity monitors/unit	5	+	+1	16
2. other systems, 4 components, 1 source	30	+	5	(23+60)

For the systems, each component was considered to require 1/4 of the five days/month, hence total time/component = (23 x m x 15).

This formula is considered appropriate for both extractive and *in situ* monitors, for a single source.

For multisources, the extractive units are increased by 10%/unit, and the *in situ* by 100%/unit. Therefore the total maintenance cost is calculated as 16 x number of opacity meters + (23 + 15 x number of components) x (0.9 + 0.7 x number of sources) for extractive + (23 x 15 x number of components) x number of sources for *in situ* systems.

The answer is obtained in mandays of maintenance. The cost is estimated using a cost of $250/day (Canadian dollars, 1988) or about $30/hour.

A.11 Data Processing Costs

It is assumed that each CEMS would generate an internal data processing and handling cost. Underlying assumptions are that each source would require about two days per quarter for a single parameter; extra parameters would produce an increment of 20%; and extra sources would require a 50% increment.

The basic cost of the manday was taken as $750 (Canadian dollars, 1988).

A.12 Source Characteristics

To take into account varying degrees of difficulty associated with the source gases, a series of factors are used.

Each source has to have defined high, medium or low values for the three variables: temperature, corrosivity and dust loading of the gas stream. The medium values are taken as typical for the boiler industry off gases and are assigned a value of 1.0. Other values in the matrix are assigned as shown:

	High	Med	Low
Temperature	1.5	1.0	0.7
Corrosivity	1.5	1.0	0.7
Dust loading	1.3	1.0	0.7

To obtain the overall factor, the highest factor in the range is selected. Individual factors are not added or multiplied.

This factor is then used to multiply the sample conditioning system, commissions and maintenance costs, as these in general are not susceptible to the gas conditions.

APPENDIX B

Stack Sampling Cost Estimates

APPENDIX B: STACK SAMPLING COST ESTIMATES

It is estimated that 90-95% of the testing performed for government purposes is done by outside firms. The following estimates are based on costs that would be charged by outside firms.

There are two major components to the stack sampling activity:

1) obtain the sample for analysis
2) analysis

To arrive at the cost on a process-specific basis, the following information sheets have been developed: (in this appendix all cost data presented is 1985 Canadian dollars)

1) Contaminant fact sheet -

   For each contaminant of concern a contaminant fact sheet has been prepared (Appendix E). The Fact Sheet provides a brief description of the contaminant, identifies recognized methods of sampling and analysis, and provides a brief description of the sampling and analytical protocol.

2) Summary of stack samplings costs -

   For each of the five categories of sampling - Method 5, Modified Method 5, VOST, Grab and Instrumentation - a base cost to perform one complete test (consists of three samples) has been calculated.

   The source sampling costing was developed using the IMET detailed budget preparation program for a base situation for each of the sampling types identified from the contaminant fact sheets. The base situations include the following criteria:

1) the test site was within 50 km of Toronto;
2) access to the source was via flat roof top and the sampling location was less than 30 ft in elevation from the ground
3) standard MOE compliance quality report would be produced
4) plant process operating data was provided by a plant engineer familiar with the particular process
5) the testing would include methods 1 through 4 sampling procedures - volumetric flow, molecular weight, temperature, etc. - to enable mass emission calculations
6) the stack is 2m or less in diameter
7) the stack gas temperature is 300°C or less
8) the sampling program consists of sampling one source only

To accommodate variance from the base situations, incremental costs for each variance factor were developed, including the cost variance when more than one source at the same location is tested.

3) Summary of analytical costs -

For each contaminant, the appropriate analytical methodology has been identified with reference to the contaminant fact sheet, and analytical costs obtained from commercial laboratories. A total analytical cost for three runs is also calculated. These costs are summarized in Table B.1.

4) Stack sampling cost calculation sheet -

A stack sampling cost calculation sheet has been prepared for each process identified in the appropriate industrial sectors (refer to Appendix D). The contaminants emitted from the process are identified. Reference is made to the contaminant Fact Sheet where the sampling and analytical methods for that specific source are selected. Reference is then made to the summary of stack sampling cost table and the summary of analytical costs to insert the appropriate costs.

Contaminants are grouped on the cost calculation sheet according to method of sampling. Often several contaminants can be sampled at the same time using the same sampling equipment. For example, testing a MSW incinerator for particulate, heavy metal, HCl, and HF can be performed using method 5, at a base cost of $7,000.00 (refer to Table B.2). A subtotal cost for that activity is given as well as the total cost of the entire test program.

In addition to the cost of hiring an outside firm to perform the testing, time must be spent by the company, co-ordinating the activities, monitoring the process operation during sampling, reviewing the report and discussing programs and results with the Ministry.

It is estimated that approximately 20% of the quoted cost for each stack sampling project is required for internal management.

TABLE B.1

SUMMARY OF STACK SAMPLING COSTS

Contaminant	Sampling and Analytical Methodology	Price/Analysis (based on higher price of solid or liquid)	Proofs /train	Samples /train	# trains	Total Price (analytical) & misc. prep. & cleaning & materials
Dioxins & furans	MM5/GC/MS	790.00	3	3	4	18,960 (20,000)
Chlorinated benzenes	MM5/GC/MS	220.00	3	3	4	5,280 (5,500)
"	MM5/GC	190.00	3	3	4	4,560 (4,750)
PCBs	MM5/GC/MS	230.00	3	3	4	5,520 (5,750)
"	MM5/GC	160.00	3	3	4	3,840 (4,250)
PAHs	MM5/GC/MS	340.00	3	3	4	8,160 (8,500)
"	MM5/GC	250.00	3	3	4	6,000 (6,250)
Chlorinated phenols	MM5/GC/MS	220.00	3	3	4	5,280 (5,500)
Chlorinated benzenes, Chlorinated phenols, PCBs, PAHs	MM5/GC/MS	790.00	3	3	4	18,960 (20,000)
Dioxins, furans, PAH, chlorophenols, chlorobenzenes, PCBs	MM5/GC/MS	1,350.00	3	3	4	32,400 (33,500)
Extractable organics (EPA 625)	MM5/GC/MS	650.00	3	3	4	15,600 (16,000)
Full scan GC/MS Extractibles (EPA 625)	MM5/GC/MS	790.00	3	3	4	18,960 (20,000)

TABLE B.1, continued

Contaminant	Sampling and Analytical Methodology	Price/Analysis (based on higher price of solid or liquid)	Proofs /train	Samples /train	# trains	Total Price (analytical) & misc. prep. & cleaning & materials
VOST Traps (selected compounds) EPA 624	VOST/GC/MS	290.00	2	2	4	4,640 (5,000)
Asbestos	M5/optical phase contrast microscopy	50.00	1	1	3	300
THC (Organic alkanes, alkenes, aromatic hydrocarbons)	EPA method 25A using continuous analyser instead of VOST/GC/MC	-	-	-	-	-
Metals	MS/ICAP or AAS	12.50-19.00	2	3	3	187.50-285.00
Metals scan (except mercury)	MS/ICAP	52.00 *(DRL notes 5.00 for each additional element)	2	3	3	780
Ammonia	impingers/ colorimetric	15.00-20.00	1	1	3	90-120

TABLE B.1, continued

Contaminant	Sampling and Analytical Methodology	Price/Analysis (based on higher price of solid or liquid)	Proofs /train	Samples /train	# trains	Total Price (analytical) & misc. prep. & cleaning & materials
Potassium cyanide	MS/specific ion electrode	15.00-20.00	2	3	3	225-300
Hydrogen cyanide	MS/specific ion electrode	15.00-20.00	2	3	3	225-300
Sodium cyanide	MS/specific ion electrode	15.00-20.00	2	3	3	225-300
Calcium cyanide	MS/specific ion electrode	15.00-20.00	2	3	3	225-300
Potassium hydroxide	M5/AAS	19.00	2	3	3	285
Chlorine dioxide	impinger/ titration	15.00-20.00	1	1	3	90-120
TRS	impinger/ titration or	15.00-20.00	1	1	3	90-120
	cont. UV analyser	-	-	-	-	-
Nickel carbonyl	impinger or charcoal tube/AAS	19.00	1	1	3	114
Toluene diisocyanate	impinger/ colorimetry	20.00	1	1	3	120
Methyl diphenyl diisocyanate	impinger/ colorimetry	20.00	1	1	3	120
Thiourea	M5/HPLC	150.00	2	3	3	2250

TABLE B.1, continued

Contaminant	Sampling and Analytical Methodology	Price/Analysis (based on higher price of solid or liquid)	Proofs /train	Samples /train	# trains	Total Price (analytical) & misc. prep. & cleaning & materials
Ammonia	impinger/IR or colorimetric	15.00-20.00	1	1	3	90-120
Silica	M5/x-ray diffraction	24.00				
Chlorine	impinger/ titration	15.00-20.00	1	1	3	90-120
HCl	impinger/ titration	15.00-20.00	1	1	3	90-120
	or ion chromatography	12.50	1	1	3	75
H_2S	impinger/ titration	15.00-20.00	1	1	3	90-120
Merrcaptans	analyse as TRS cont. analyser or	-	-	-	-	-
SO_2 (see sulfuric acid)	cont. analyser	-	-	-	-	-
	or impinger/ titration	15.00-20.00	1	1	3	90-120
Nitrous Oxide	cont. NDIR analyser or	-	-	-	-	-

TABLE B.1, continued

Contaminant	Sampling and Analytical Methodology	Price/Analysis (based on higher price of solid or liquid)	Proofs /train	Samples /train	# trains	Total Price (analytical) & misc. prep. & cleaning & materials
Phosphine	charcoal tube/	19.00	1	1	3	114
(see Arsine)	AAS or					
Arsine	charcoal tube/	19.00	1	1	3	114
(see phosphine)	AAS					
Nitrogen	cont. chemi-	-	-	-	-	-
Oxide	luminescent					
	analyser or					
	impinger/	15.00-20.00	1	1	3	90-120
	colorimetry					
	(or ion	12.50	1	1	3	75
	chromatography)					
	or UV	?	1	1	3	
	spectrometry					
Sulfuric (see SO_2)	impinger/	15.00-20.00				
Acid	titration					
Fluorides	MS/colorimetry,	15.00-20.00	2	3	3	225-300
(see	specific ion	15.00-20.00	2	3	3	225-300
Anion scan)	electrode, or					
	ion chromato-	15.00-20.00	2	3	3	187.50
	graphy					
Anion scan	MS/ion	47.00	2	3	3	705
(chloride,	chromatography					
Fluoride etc)	impinger/	15.00-20.00	1	1	3	90-120

TABLE B.1, continued

Contaminant	Sampling and Analytical Methodology	Price/Analysis (based on higher price of solid or liquid)	Proofs /train	Samples /train	# trains	Total Price (analytical) & misc. prep. & cleaning & materials
Ozone	colorimetry					
Sodium Hydroxide	Method 5/ titration	15.00-20.00	2	3	3	225-300

TABLE B.2

MONITORING COSTS

STACK SAMPLING
COST CALCULATION SHEET

INDUSTRY: MSW INCINERATOR
PROCESS: MASS BURNING - NO HEAT RECOVERY

	Sampling							
		Adjustment				Total		
Contaminant	Base	HT	DIA	T	DIS	SAMP	Analysis	Total
Particulate	7,000	300	450	200		7,950		7,950
heavy metals							780	780
HCL							280	280
HF							120	120
Subtotal							120	120
PCDD/PCDF	9,500					9,500	20,000	29,500
NO_x	4,000					4,000		4,000
SO_2								
TOTAL	20,500	300	450	200	0	21,450	21,300	42,750

Note:

HT - Height
DIA - Diameter
T - Temperature
DIS - Distance

APPENDIX C

Sample Cost Calculation for Iron Foundries

APPENDIX C: SAMPLE COST CALCULATION FOR IRON FOUNDRIES

From the monitoring cost sheets (Appendix D) determine the stack sampling costs and capital and operating costs associated with continuous emission monitoring for the sample plant.

Step 1

Sampling and Analysis costs for the foundries sector are obtained from the pages labelled "stack sampling" for Iron Foundries.

Iron Foundries	$1.12 million

Step 2

This figure is multiplied by a factor of 1.2 to add in the costs associated with management and liaison. The justification for associated with management and liaison. The justification for the 20% increase is based on the in-field experience of IMET.

Iron Foundries	$1.34 million

Step 3

To bring this number into 1986 $ it is multiplied by a factor of .93%.

Iron Foundries	$1.25 million

Step 4

Continuous Operating costs are obtained from the pages labelled "continuous emission monitoring system costs" for Iron Foundries. Taking the total annual operating costs from these pages, results in the following numbers:

Iron Foundries	\$ 52,400
	\$114,480
	\$ 81,440

In the case of Iron foundries the cost of \$52,400 is for five stacks emitting particulates (Note: table rows labelled # of sources per plant and analyser type). As there are 110 stacks in the plant emitting particulates, the value of \$52,400 is multiplied by 110/5 to get a value of \$1.153 million.

There are 13 stacks in the plant emitting SO_2, NO_x etc. The value of \$114,480 is the operating cost for 5 stacks. Therefore this figure is multiplied by 2 to get \$.228 million (i.e. cost for 10 stacks). The final figure is for 3 stacks and remains at \$81,440. Adding \$.228 million and \$.0814 million results in the continuous emission monitoring cost of \$.31 million for the plants 13 stacks emitting SO_2 and NO_x etc.

The total cost of continuous emission monitoring is calculated by adding the cost for the particulate stacks plus the cost for the other stacks (i.e. \$1.153 million + \$.31 million = \$1.46 million). Factoring the resulting number up by 1.2 takes into account management time in the monitoring process. (\$1.46 million * 1.2 = \$1.75 million). Deflating this last calculation by 7% creates a cost in 1986 \$ (i.e. \$1.75 million * .93% = \$1.62 million).

Step 5

In order to calculate the commissioning and installation costs for iron and steel foundries the pages labelled "continuous emission monitoring system costs" should be consulted. The row labelled total installation and commission reveals:

Iron Foundries	$203,300
	$453,900
	$324,500

Using the same multipliers as above to take into account the number of stacks at the sample plant results in a total value of $5.705 million (i.e. ($203,300*22) + ($453,900*2) + ($324,500) = $5,704,900).

Applying a factor of .97% deflates the above total to 1986 $. (i.e. $5.704 million * .97% = $5.56 million)

Step 6

To calculate total costs for the entire iron foundry sector, the preceding totals are multiplied by a factor of 3.08. This is because the sample plant represents 32.5% of the sector capacity. The following values result:

Sampling & Analysis	$ 3.85 million
Continuous Operating	$ 5.0 million
Commissioning & Installation	$ 17.13 million

Step 7

This step involves calculating the costs associated with each of the three levels of control: NSPS, BACT and LAER. It should be noted that NSPS costs are based on sampling once every 15 years, the BACT costs every 3 years and the LAER costs every year. It should also be noted that there is no continuous emission monitoring associated with NSPS level abatement.

The following table can be constructed:

	Level 3 (NSPS)		Level 2 (BACT)		Level 1 (LAER)	
	Operating	Capital	Operating	Capital	Operating	Capital
Iron Foundries	$.26 million	--	$5.77 million	$17.1 million	$8.85 million	$17.1 million

Step 8

This step involves constructing the cost profiles for the five scenarios. Scenarios A and B are the same, as the emitted contaminants require Level 1 abatement and monitoring procedures.

Scenario C requires Level 2 abatement controls and therefore the same level of monitoring.

Scenario D demands the same level of monitoring as Scenario A.

Scenario E is phased so that monitoring equipment and operating procedures are emplaced to cope with first priority contaminants as designated under Scenario A. The remaining equipment and operating procedures necessary to cope with the rest of the contaminants are emplaced in Phase 2.

APPENDIX D

Monitoring Costs:

- Continuous Emission Monitoring System Costs
- Stack Sampling Cost Calculation Sheets

APPENDIX D - TABLE OF CONTENTS

2711	Pulp and Paper Kraft	- CEM - Opacity, TRS, SO_2, NO_x, CO, O_2
		- Stack - Part. MM5, TRS, SO_2, NO_x, CO
2912	Steel Foundry	- CEM - Opacity
		- CEM - SO_2, NO_x, O_2
2941	Iron Foundry	- CEM - Opacity SO_2, NO_x, O_2
		- CEM - Opacity
		- Stack - Part. MM5, SO_2, NO_x, THC
2971	Copper/Copper Alloy	- CEM - Opacity
2959	Nonferrous Smelters	- CEM - Opacity, SO_2
3255	Aluminum Wheels	- CEM - Opacity
		- Stack - Part.
3255	Brake Manufacturing	- CEM - Opacity
3259	Wet Cell Batteries	- CEM - Opacity
3521	Cement Coolers	- CEM - Opacity
3521	Cement Kilns	- CEM - Opacity, SO_2, NO_x, O_2
		- Stack - Part, SO_2, NO_x
3581	Lime Industry	- CEM - Opacity, NO_x, SO_2, O_2
		- Stack Part., NO_x, SO_2
3711	Inorganic Chemicals	
	. Ammonium Nitrate	- CEM - Opacity
	. Nitric Acid	- CEM - Opacity, NO_2, SO_2, O_2
		- Stack - eleven contaminants
3611	Petroleum Refineries	
	. Heater/Boilers	- CEM - SO_2, NO_x, O_2
	. FCCU	- CEM - SO_2, NO_x, O_2, Opacity
	. Sulphur Plant	- CEM - SO_2, O_2
		- Stack - Part, MM5, VOST, SO_2, NO_x
3699	Asphalt Paving	- CEM - Opacity
		- Stack - Part.
3712	Industrial Organic	- CEM - NO_x, O_2
		- CEM - NO_x, O_2, HCl
		- Stack - VOST, NO_x, Part, CFCF, Metals
3731	Plastics & Synthetics	- Stack - VOST
3751	Paint & Varnish	- CEM - Opacity
		- Stack - Part., VOST
3799	Dry Cleaning	- Stack - VOST

APPENDIX D - TABLE OF CONTENTS, continued

4911 Power Generation	- CEM - Opacity, SO_2, NO_x, O_2
4999 Sewage Sludge Incineration	- CEM - Opacity, NO_x, SO_2, O_2, HCl - Stack - Part, Metals, HCl, Tr. Org. SO_2, NO_x, THC, CO
4999 Municipal Incineration	- CEM - Opacity, NO_x, SO_2, CO_2, [illegible] - Stack - Part, Metals, HCl, SO_2 NO_x, THC
4999 Transfer Stations	- CEM - Opacity - Stack - Part., VOST

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CONTINUOUS EMISSION MONITORING SYSTEM COSTS

INDUSTRY                   PULP&PAPER/KRAFT
SIC                              2711
# OF SOURCES/PLANT                 3
ANALYSER TYPE              OPACITY,TRS,SO2,NOX,CO,O2
GAS TEMP                   MED
COMMENTS                   STACK LADDER/PLATFORM RETEROFIT
                           @ $50000 EACH STACK
COSTS OF INSTRUMENTS TO BE USED & TYPE(E/I)

INSTRUMENT  COST/UNIT EXTRACTIVE    INSITU     TOTAL
                             1/0       1/0
OPACITY         25000          0         1     75000
SO2             20000          1         0     20000
NOx             15000          1         0     15000
O2               6000          1         0      6000
CO2              7000          0         0         0
CO               7000          1         0      7000
TRS             25000          1         0     25000
OTHER           70000          0         0         0

                               5         1    148000

FACTORED COST ESTIMATE
NUMBER OF SOURCES                        3
NUMBER OF PARAMETERS                     6

STACK GAS CONDITIONS
                             LOW    MEDIUM       HIGH    FACTOR
TEMPERATURE    1/0             0         1          0         1
CORROSIVITY    1/0             0         1          0         1
DUST LOADING   1/0             0         1          0         1

                                TOTAL COST            BASE COST

INSTRUMENT COST                     148000
SAMPLE CONDITIONING                  98000                70000
DATA ACQUISITION COST                17000                10000
INSTALLATION COST                    23000                 5000
RETROFIT COST                       150000                50000
CERTIFICATION COST                   15000                 9000
COMMISSIONING COST                   17500                 5000
                                    ------               ------
TOTAL INSTALLATION & COMMISSION     468500               149000

AUDITING COST                        12000                 4000
MAINTENANCE COST                     66240                  400
DATA PROCESSING COST                 24000                  750
                                    ------               ------
TOTAL ANNUAL OPERATING COSTS        102240                 5150
```

MONITORING COSTS

STACK SAMPLING
COST CALCULATION SHEET

INDUSTRY: PULP&PAPER-KRAFT
SIC: 2711

LOCATION: NORTHERN ONTARIO
COST BASIS: PER SITE
3 STACKS PART,TRS,SO2,NOX,CO
1 STACK PART,SO2
3 STACKS PART,PAH,SO2,NOX

CONTAMINANT	SAMPLING						ANALYSIS		TOTAL
	BASE	ADJUSTMENT HT	DIA	T	DIS	TOTAL SAMP			
PART	31080				900	31980			31980
MM5	23340				1400	24740	18750		43490
TRS,NOX,SO2, CO	13200				900	14100			14100
SO2,NOX	6600				900	7500			7500
TOTAL	74220	0	0	0	4100	78320	18750	0	97070

NOTE: HT -HEIGHT
DIA -DIAMETER
T -TEMPERATURE
DIS -DISTANCE

```
CONTINUOUS EMISSION MONITORING SYSTEM COSTS

INDUSTRY                STEEL FOUNDERIES
SIC                           2912
# OF SOURCES/PLANT               5
ANALYSER TYPE           OPACITY
GAS TEMP                MED
COMMENTS                STACK LADDER/PLATFORM RETEROFIT
                        @ $15000 EACH STACK
COSTS OF INSTRUMENTS TO BE USED & TYPE(E/I)

INSTRUMENT  COST/UNIT EXTRACTIVE   INSITU    TOTAL
                             1/0      1/0
OPACITY         25000          0        1   125000
SO2             20000          0        0        0
NOx             15000          0        0        0
O2               6000          0        0        0
CO2              7000          0        0        0
CO               7000          0        0        0
TRS             25000          0        0        0
OTHER               0          0        0        0

                               0        1   125000

FACTORED COST ESTIMATE
NUMBER OF SOURCES                       5
NUMBER OF PARAMETERS                    1

STACK GAS CONDITIONS
                             LOW   MEDIUM     HIGH   FACTOR
TEMPERATURE    1/0             0        1        0        1
CORROSIVITY    1/0             0        1        0        1
DUST LOADING   1/0             0        1        0        1

                              TOTAL COST         BASE COST

INSTRUMENT COST                   125000
SAMPLE CONDITIONING                    0             70000
DATA ACQUISITION COST               7000              5000
INSTALLATION COST                  25000              5000
RETROFIT COST                      75000             15000
CERTIFICATION COST                 15000              9000
COMMISSIONING COST                  9000              5000
                                  ------            ------
TOTAL INSTALLATION & COMMISSION   256000            109000

AUDITING COST                      12000              4000
MAINTENANCE COST                   32000               400
DATA PROCESSING COST               18000               750
                                  ------            ------
TOTAL ANNUAL OPERATING COSTS       62000              5150
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CONTINUOUS EMISSION MONITORING SYSTEM COSTS

INDUSTRY                 STEEL FOUNDERIES
SIC                            2912
# OF SOURCES/PLANT                5
ANALYSER TYPE            SO2,NOX,O2
GAS TEMP                 MED
COMMENTS                 STACK LADDER/PLATFORM RETEROFIT
                         @ $15000 EACH STACK
COSTS OF INSTRUMENTS TO BE USED & TYPE(E/I)

INSTRUMENT   COST/UNIT EXTRACTIVE    INSITU    TOTAL
                              1/0       1/0
OPACITY          25000          0         0        0
SO2              20000          1         0    20000
NOx              15000          1         0    15000
O2                6000          1         0     6000
CO2               7000          0         0        0
CO                7000          0         0        0
TRS              25000          0         0        0
OTHER                0          0         0        0

                                3         0    41000

FACTORED COST ESTIMATE
NUMBER OF SOURCES                         5
NUMBER OF PARAMETERS                      3

STACK GAS CONDITIONS
                           LOW   MEDIUM      HIGH   FACTOR
TEMPERATURE    1/0           0        1         0        1
CORROSIVITY    1/0           0        1         0        1
DUST LOADING   1/0           0        1         0        1

                              TOTAL COST         BASE COST

INSTRUMENT COST                    41000
SAMPLE CONDITIONING               126000             70000
DATA ACQUISITION COST              16000             10000
INSTALLATION COST                  11000              5000
RETROFIT COST                      75000             15000
CERTIFICATION COST                 16200              9000
COMMISSIONING COST                 14400              5000
                                  ------            ------
TOTAL INSTALLATION & COMMISSION   299600            114000

AUDITING COST                      14400              4000
MAINTENANCE COST                   38080               400
DATA PROCESSING COST               25200               750
                                  ------            ------
TOTAL ANNUAL OPERATING COSTS       77680              5150
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CONTINUOUS EMISSION MONITORING SYSTEM COSTS

INDUSTRY                 STEEL FOUNDERIES
SIC                            2912
# OF SOURCES/PLANT               5
ANALYSER TYPE            OPACITY,SO2,NOX,O2
GAS TEMP                 MED
COMMENTS                 STACK LADDER/PLATFORM RETEROFIT
                         @ $15000 EACH STACK
COSTS OF INSTRUMENTS TO BE USED & TYPE(E/I)

INSTRUMENT  COST/UNIT EXTRACTIVE    INSITU     TOTAL
                             1/0       1/0
OPACITY         25000          0         1    125000
SO2             20000          1         0     20000
NOx             15000          1         0     15000
O2               6000          1         0      6000
CO2              7000          0         0         0
CO               7000          0         0         0
TRS             25000          0         0         0
OTHER               0          0         0         0

                               3         1    166000

FACTORED COST ESTIMATE
NUMBER OF SOURCES                        5
NUMBER OF PARAMETERS                     4

STACK GAS CONDITIONS
                          LOW     MEDIUM       HIGH    FACTOR
TEMPERATURE    1/0          0          1          0         1
CORROSIVITY    1/0          0          1          0         1
DUST LOADING   1/0          0          1          0         1

                            TOTAL COST           BASE COST

INSTRUMENT COST                 166000
SAMPLE CONDITIONING             126000               70000
DATA ACQUISITION COST            17000               10000
INSTALLATION COST                36000                5000
RETROFIT COST                    75000               15000
CERTIFICATION COST               16800                9000
COMMISSIONING COST               17100                5000
                                ------              ------
TOTAL INSTALLATION & COMMISSION 453900              114000

AUDITING COST                    15600                4000
MAINTENANCE COST                 70080                 400
DATA PROCESSING COST             28800                 750
                                ------              ------
TOTAL ANNUAL OPERATING COSTS    114480                5150
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CONTINUOUS EMISSION MONITORING SYSTEM COSTS

INDUSTRY	IRON FOUNDARIES
SIC	2941
# OF SOURCES/PLANT	5
ANALYSER TYPE	OPACITY,SO2,NOX,O2
GAS TEMP	MED
COMMENTS	STACK LADDER/PLATFORM RETEROFIT @ $15000 EACH STACK

COSTS OF INSTRUMENTS TO BE USED & TYPE(E/I)

INSTRUMENT	COST/UNIT	EXTRACTIVE 1/0	INSITU 1/0	TOTAL
OPACITY	25000	0	1	125000
SO2	20000	1	0	20000
NOx	15000	1	0	15000
O2	6000	1	0	6000
CO2	7000	0	0	0
CO	7000	0	0	0
TRS	25000	0	0	0
OTHER	70000	0	0	0
		3	1	166000

FACTORED COST ESTIMATE

NUMBER OF SOURCES	5
NUMBER OF PARAMETERS	4

STACK GAS CONDITIONS

		LOW	MEDIUM	HIGH	FACTOR
TEMPERATURE	1/0	0	1	0	1
CORROSIVITY	1/0	0	1	0	1
DUST LOADING	1/0	0	1	0	1

	TOTAL COST	BASE COST
INSTRUMENT COST	166000	
SAMPLE CONDITIONING	126000	70000
DATA ACQUISITION COST	17000	10000
INSTALLATION COST	36000	5000
RETROFIT COST	75000	15000
CERTIFICATION COST	16800	9000
COMMISSIONING COST	17100	5000
	------	------
TOTAL INSTALLATION & COMMISSION	453900	114000
AUDITING COST	15600	4000
MAINTENANCE COST	70080	400
DATA PROCESSING COST	28800	750
	------	------
TOTAL ANNUAL OPERATING COSTS	114480	5150

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CONTINUOUS EMISSION MONITORING SYSTEM COSTS

INDUSTRY                   IRON FOUNDARIES
SIC                              2941
# OF SOURCES/PLANT                  5
ANALYSER TYPE              OPACITY
GAS TEMP                   LOW
COMMENTS                   STACK LADDER/PLATFORM RETEROFIT
                           @ $5000 EACH STACK
COSTS OF INSTRUMENTS TO BE USED & TYPE(E/I)

INSTRUMENT  COST/UNIT EXTRACTIVE   INSITU    TOTAL
                             1/0      1/0
OPACITY         25000          0        1   125000
SO2             20000          0        0        0
NOx             15000          0        0        0
O2               6000          0        0        0
CO2              7000          0        0        0
CO               7000          0        0        0
TRS             25000          0        0        0
OTHER           70000          0        0        0

                               0        1   125000

FACTORED COST ESTIMATE
NUMBER OF SOURCES                       5
NUMBER OF PARAMETERS                    1

STACK GAS CONDITIONS
                             LOW   MEDIUM     HIGH   FACTOR
TEMPERATURE   1/0              1        0        0      0.7
CORROSIVITY   1/0              1        0        0      0.7
DUST LOADING  1/0              1        0        0      0.7

                               TOTAL COST         BASE COST

INSTRUMENT COST                    125000
SAMPLE CONDITIONING                     0             70000
DATA ACQUISITION COST                7000              5000
INSTALLATION COST                   25000              5000
RETROFIT COST                       25000              5000
CERTIFICATION COST                  15000              9000
COMMISSIONING COST                   6300              5000
                                   ------            ------
TOTAL INSTALLATION & COMMISSION    203300             99000

AUDITING COST                       12000              4000
MAINTENANCE COST                    22400               400
DATA PROCESSING COST                18000               750
                                   ------            ------
TOTAL ANNUAL OPERATING COSTS        52400              5150
```

MONITORING COSTS

STACK SAMPLING
COST CALCULATION SHEET

INDUSTRY:	IRON FOUNDRIES
SIC:	2941
LOCATION:	ST. CATHERINES
COST BASIS:	INDIVIDUAL PLANTS COMPANY - STEEL D 110 STACKS PART,METALS 13 STACKS SO2,NOX,THC,PAH,PM,METALS

CONTAMINANT	SAMPLING						ANALYSIS	TOTAL
	BASE	ADJUSTMENT				TOTAL SAMP		
		HT	DIA	T	DIS			
COMPANY D								
PARTICULATE	747460				400	747860		747860
METALS							130380	130380
MM5	107540				600	108140	81250	189390
SO2,NOX,THC	50100				400	50500		50500
TOTAL	905100	0	0	0	1400	906500	211630	1118130

NOTE: HT -HEIGHT
DIA -DIAMETER
T -TEMPERATURE
DIS -DISTANCE

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CONTINUOUS EMISSION MONITORING SYSTEM COSTS

INDUSTRY                    CCOPPER/COPPER ALLOYS
SIC                                2971
# OF SOURCES/PLANT                   4
ANALYSER TYPE               OPACITY
GAS TEMP                    MED
COMMENTS                    STACK LADDER/PLATFORM RETEROFIT
                            @ $15000 EACH STACK
COSTS OF INSTRUMENTS TO BE USED & TYPE(E/I)

INSTRUMENT  COST/UNIT EXTRACTIVE   INSITU    TOTAL
                             1/0      1/0
OPACITY          25000         0        1   100000
SO2              20000         0        0        0
NOx              15000         0        0        0
O2                6000         0        0        0
CO2               7000         0        0        0
CO                7000         0        0        0
TRS              25000         0        0        0
OTHER            70000         0        0        0

                               0        1   100000

FACTORED COST ESTIMATE
NUMBER OF SOURCES                       4
NUMBER OF PARAMETERS                    1

STACK GAS CONDITIONS
                             LOW   MEDIUM     HIGH   FACTOR
TEMPERATURE    1/0             0        1        0        1
CORROSIVITY    1/0             0        1        0        1
DUST LOADING   1/0             0        1        0        1

                                TOTAL COST        BASE COST

INSTRUMENT COST                     100000
SAMPLE CONDITIONING                      0            70000
DATA ACQUISITION COST                13000            10000
INSTALLATION COST                    20000             5000
RETROFIT COST                        60000            15000
CERTIFICATION COST                   14000             9000
COMMISSIONING COST                    8000             5000
                                    ------           ------
TOTAL INSTALLATION & COMMISSION     215000           114000

AUDITING COST                        10000             4000
MAINTENANCE COST                     25600              400
DATA PROCESSING COST                 15000              750
                                    ------           ------
TOTAL ANNUAL OPERATING COSTS         50600             5150
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CONTINUOUS EMISSION MONITORING SYSTEM COSTS

INDUSTRY               NONFERROUS SMELTERS
SIC                            2959
# OF SOURCES/PLANT               5
ANALYSER TYPE          OPACITY,SO2
GAS TEMP               AMBIENT
COMMENTS               UNDEFINED SOURCES AT CO. A +\- 300

COSTS OF INSTRUMENTS TO BE USED & TYPE(E/I)

INSTRUMENT  COST/UNIT EXTRACTIVE    INSITU    TOTAL
                             1/0       1/0
OPACITY         25000          0         1   125000
SO2             20000          1         0    20000
NOx             15000          0         0        0
O2               6000          1         0     6000
CO2              7000          0         0        0
CO               7000          0         0        0
TRS             25000          0         0        0
OTHER               0          0         0        0

                               2         1   151000

FACTORED COST ESTIMATE
NUMBER OF SOURCES                        5
NUMBER OF PARAMETERS                     3

STACK GAS CONDITIONS
                             LOW    MEDIUM     HIGH   FACTOR
TEMPERATURE    1/0             1         0        0      0.7
CORROSIVITY    1/0             1         0        0      0.7
DUST LOADING   1/0             1         0        0      0.7

                              TOTAL COST         BASE COST

INSTRUMENT COST                   151000
SAMPLE CONDITIONING                88200             70000
DATA ACQUISITION COST              16000             10000
INSTALLATION COST                  36000              5000
RETROFIT COST                      25000              5000
CERTIFICATION COST                 16200              9000
COMMISSIONING COST                 10080              5000
                                  ------            ------
TOTAL INSTALLATION & COMMISSION   342480            104000

AUDITING COST                      14400              4000
MAINTENANCE COST                   43176               400
DATA PROCESSING COST               25200               750
                                  ------            ------
TOTAL ANNUAL OPERATING COSTS       82776              5150
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CONTINUOUS EMISSION MONITORING SYSTEM COSTS

INDUSTRY	ALUMIUM WHEELS
SIC	
# OF SOURCES/PLANT	2
ANALYSER TYPE	OPACITY
GAS TEMP	LOW
COMMENTS	STACK LADDER/PLATFORM RETEROFIT @ $5000 EACH STACK

COSTS OF INSTRUMENTS TO BE USED & TYPE(E/I)

INSTRUMENT	COST/UNIT	EXTRACTIVE 1/0	INSITU 1/0	TOTAL
OPACITY	25000	0	1	50000
SO2	20000	0	0	0
NOx	15000	0	0	0
O2	6000	0	0	0
CO2	7000	0	0	0
CO	7000	0	0	0
TRS	25000	0	0	0
OTHER	70000	0	0	0
		0	1	50000

FACTORED COST ESTIMATE

NUMBER OF SOURCES	2
NUMBER OF PARAMETERS	1

STACK GAS CONDITIONS

		LOW	MEDIUM	HIGH	FACTOR
TEMPERATURE	1/0	1	0	0	0.7
CORROSIVITY	1/0	1	0	0	0.7
DUST LOADING	1/0	1	0	0	0.7

	TOTAL COST	BASE COST
INSTRUMENT COST	50000	
SAMPLE CONDITIONING	0	70000
DATA ACQUISITION COST	5500	5000
INSTALLATION COST	10000	5000
RETROFIT COST	10000	5000
CERTIFICATION COST	12000	9000
COMMISSIONING COST	4200	5000
	------	------
TOTAL INSTALLATION & COMMISSION	91700	99000
AUDITING COST	6000	4000
MAINTENANCE COST	8960	400
DATA PROCESSING COST	9000	750
	------	------
TOTAL ANNUAL OPERATING COSTS	23960	5150

MONITORING COSTS

STACK SAMPLING
COST CALCULATION SHEET

INDUSTRY: ALUMINUM WHEEL
SIC:

LOCATION: TORONTO AREA
COST BASIS: PER PLANT
2 STACKS-PART,METALS

CONTAMINANT	SAMPLING						ANALYSIS	TOTAL
	BASE	ADJUSTMENT				TOTAL		
		HT	DIA	T	DIS	SAMP		
PARTICULATE	7000					7000		7000
METALS							1060	1060
TOTAL	7000	0	0	0	0	7000	1060	8060

NOTE:HT -HEIGHT
DIA -DIAMETER
T -TEMPERATURE
DIS -DISTANCE

CONTINUOUS EMISSION MONITORING SYSTEM COSTS

INDUSTRY	BRAKE MANUFACTURING
SIC	3255
# OF SOURCES/PLANT	1
ANALYSER TYPE	OPACITY
GAS TEMP	LOW
COMMENTS	STACK LADDER/PLATFORM RETEROFIT @ $5000 EACH STACK

COSTS OF INSTRUMENTS TO BE USED & TYPE(E/I)

INSTRUMENT	COST/UNIT	EXTRACTIVE 1/0	INSITU 1/0	TOTAL
OPACITY	25000	0	1	25000
SO2	20000	0	0	0
NOx	15000	0	0	0
O2	6000	0	0	0
CO2	7000	0	0	0
CO	7000	0	0	0
TRS	25000	0	0	0
OTHER	70000	0	0	0
		0	1	25000

FACTORED COST ESTIMATE

NUMBER OF SOURCES	1
NUMBER OF PARAMETERS	1

STACK GAS CONDITIONS

		LOW	MEDIUM	HIGH	FACTOR
TEMPERATURE	1/0	1	0	0	0.7
CORROSIVITY	1/0	1	0	0	0.7
DUST LOADING	1/0	1	0	0	0.7

	TOTAL COST	BASE COST
INSTRUMENT COST	25000	
SAMPLE CONDITIONING	0	70000
DATA ACQUISITION COST	5000	5000
INSTALLATION COST	5000	5000
RETROFIT COST	5000	5000
CERTIFICATION COST	11000	9000
COMMISSIONING COST	3500	5000
	------	------
TOTAL INSTALLATION & COMMISSION	54500	99000
AUDITING COST	4000	4000
MAINTENANCE COST	4480	400
DATA PROCESSING COST	6000	750
	------	------
TOTAL ANNUAL OPERATING COSTS	14480	5150

CONTINUOUS EMISSION MONITORING SYSTEM COSTS

INDUSTRY	WET CELL AUTO BATTERIES
SIC	3259
# OF SOURCES/PLANT	6
ANALYSER TYPE	OPACITY
GAS TEMP	LOW
COMMENTS	STACK LADDER/PLATFORM RETEROFIT @ $5000 EACH STACK

COSTS OF INSTRUMENTS TO BE USED & TYPE(E/I)

INSTRUMENT	COST/UNIT	EXTRACTIVE 1/0	INSITU 1/0	TOTAL
OPACITY	25000	0	1	150000
SO2	20000	0	0	0
NOx	15000	0	0	0
O2	6000	0	0	0
CO2	7000	0	0	0
CO	7000	0	0	0
TRS	25000	0	0	0
OTHER	70000	0	0	0
		0	1	150000

FACTORED COST ESTIMATE

NUMBER OF SOURCES	6
NUMBER OF PARAMETERS	1

STACK GAS CONDITIONS

		LOW	MEDIUM	HIGH	FACTOR
TEMPERATURE	1/0	1	0	0	0.7
CORROSIVITY	1/0	1	0	0	0.7
DUST LOADING	1/0	1	0	0	0.7

	TOTAL COST	BASE COST
INSTRUMENT COST	150000	
SAMPLE CONDITIONING	0	70000
DATA ACQUISITION COST	7500	5000
INSTALLATION COST	30000	5000
RETROFIT COST	30000	5000
CERTIFICATION COST	16000	9000
COMMISSIONING COST	7000	5000
	------	------
TOTAL INSTALLATION & COMMISSION	240500	99000
AUDITING COST	14000	4000
MAINTENANCE COST	26880	4Q0
DATA PROCESSING COST	21000	750
	------	------
TOTAL ANNUAL OPERATING COSTS	61880	5150

CONTINUOUS EMISSION MONITORING SYSTEM COSTS

INDUSTRY	CEMENT:COOLERS
SIC	3521
# OF SOURCES/PLANT	3
ANALYSER TYPE	OPACITY
GAS TEMP	MED
COMMENTS	STACK LADDER/PLATFORM RETEROFIT @ $15000 EACH STACK

COSTS OF INSTRUMENTS TO BE USED & TYPE(E/I)

INSTRUMENT	COST/UNIT	EXTRACTIVE 1/0	INSITU 1/0	TOTAL
OPACITY	25000	0	1	75000
SO2	20000	0	0	0
NOx	15000	0	0	0
O2	6000	0	0	0
CO2	7000	0	0	0
CO	7000	0	0	0
TRS	25000	0	0	0
OTHER	70000	0	0	0
		0	1	75000

FACTORED COST ESTIMATE

NUMBER OF SOURCES	3
NUMBER OF PARAMETERS	1

STACK GAS CONDITIONS

		LOW	MEDIUM	HIGH	FACTOR
TEMPERATURE	1/0	0	1	0	1
CORROSIVITY	1/0	0	1	0	1
DUST LOADING	1/0	0	1	0	1

	TOTAL COST	BASE COST
INSTRUMENT COST	75000	
SAMPLE CONDITIONING	0	70000
DATA ACQUISITION COST	6000	5000
INSTALLATION COST	15000	5000
RETROFIT COST	45000	15000
CERTIFICATION COST	13000	9000
COMMISSIONING COST	7000	5000
	------	------
TOTAL INSTALLATION & COMMISSION	161000	109000
AUDITING COST	8000	4000
MAINTENANCE COST	19200	400
DATA PROCESSING COST	12000	750
	------	------
TOTAL ANNUAL OPERATING_COSTS	39200	5150

CONTINUOUS EMISSION MONITORING SYSTEM COSTS

INDUSTRY	CEMENT:KILNS
SIC	3521
# OF SOURCES/PLANT	3
ANALYSER TYPE	OPACITY,SO2,NOX,O2
GAS TEMP	MED
COMMENTS	STACK LADDER/PLATFORM RETEROFIT @ $100000 EACH STACK

COSTS OF INSTRUMENTS TO BE USED & TYPE(E/I)

INSTRUMENT	COST/UNIT	EXTRACTIVE 1/0	INSITU 1/0	TOTAL
OPACITY	25000	0	1	75000
SO2	20000	1	0	20000
NOx	15000	1	0	15000
O2	6000	1	0	6000
CO2	7000	0	0	0
CO	7000	0	0	0
TRS	25000	0	0	0
OTHER	70000	0	0	0
		3	1	116000

FACTORED COST ESTIMATE

NUMBER OF SOURCES	3
NUMBER OF PARAMETERS	4

STACK GAS CONDITIONS

		LOW	MEDIUM	HIGH	FACTOR
TEMPERATURE	1/0	0	1	0	1
CORROSIVITY	1/0	0	1	0	1
DUST LOADING	1/0	0	1	0	1

	TOTAL COST	BASE COST
INSTRUMENT COST	116000	
SAMPLE CONDITIONING	98000	70000
DATA ACQUISITION COST	15000	10000
INSTALLATION COST	23000	5000
RETROFIT COST	300000	100000
CERTIFICATION COST	14200	9000
COMMISSIONING COST	13300	5000
	------	------
TOTAL INSTALLATION & COMMISSION	579500	199000
AUDITING COST	10400	4000
MAINTENANCE COST	51840	400
DATA PROCESSING COST	19200	750
	------	------
TOTAL ANNUAL OPERATING COSTS	81440	5150

MONITORING COSTS

STACK SAMPLING
COST CALCULATION SHEET

INDUSTRY: CEMENT
SIC: 3521

LOCATION: TORONTO AREA
COST BASIS: INDIVIDUAL PLANT
COMPANY CEMENT A

KILNS 3 STACKS PART,SO2,NOX
COOLERS 3 STACKS PART
OTHER 44 STACKS PART

CONTAMINANT	SAMPLING BASE	ADJUSTMENT HT	DIA	T	DIS	TOTAL SAMP	ANALYSIS	TOTAL
PARTICULATE	301980	900	1350			304230	10000	314230
SO2,NOX	10600	450	300			11350		11350
TOTAL	312580	1350	1650	0	0	315580	10000	325580

NOTE: HT -HEIGHT
DIA -DIAMETER
T -TEMPERATURE
DIS -DISTANCE

CONTINUOUS EMISSION MONITORING SYSTEM COSTS

INDUSTRY	LIME INDUSTRY
SIC	3581
# OF SOURCES/PLANT	1
ANALYSER TYPE	OPACITY,NOX,SO2,O2
GAS TEMP	MED
COMMENTS	STACK LADDER/PLATFORM RETEROFIT @ $50000 EACH STACK

COSTS OF INSTRUMENTS TO BE USED & TYPE(E/I)

INSTRUMENT	COST/UNIT	EXTRACTIVE 1/0	INSITU 1/0	TOTAL
OPACITY	25000	0	1	25000
SO2	20000	1	0	20000
NOx	15000	1	0	15000
O2	6000	1	0	6000
CO2	7000	0	0	0
CO	7000	0	0	0
TRS	25000	0	0	0
OTHER	70000	0	0	0
		3	1	66000

FACTORED COST ESTIMATE

NUMBER OF SOURCES	1
NUMBER OF PARAMETERS	4

STACK GAS CONDITIONS

		LOW	MEDIUM	HIGH	FACTOR
TEMPERATURE	1/0	0	1	0	1
CORROSIVITY	1/0	0	1	0	1
DUST LOADING	1/0	0	1	0	1

	TOTAL COST	BASE COST
INSTRUMENT COST	66000	
SAMPLE CONDITIONING	70000	70000
DATA ACQUISITION COST	13000	10000
INSTALLATION COST	10000	5000
RETROFIT COST	50000	50000
CERTIFICATION COST	11600	9000
COMMISSIONING COST	9500	5000
	------	------
TOTAL INSTALLATION & COMMISSION	230100	149000
AUDITING COST	5200	4000
MAINTENANCE COST	33600	400
DATA PROCESSING COST	9600	750
	------	------
TOTAL ANNUAL OPERATING COSTS	48400	5150

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                                STACK SAMPLING
                            COST CALCULATION SHEET

                        INDUSTRY:           LIME
                        SIC:                3581

                        LOCATION:           TORONTO AREA
                        COST BASIS:         PER SITE
                                            2 STACKS PART
                                            1 STACK PART,NOX,SO2
======================================================================
CONTAMINANT                 SAMPLING                  ANALYSIS     TOTAL
======================================================================
             BASE        ADJUSTMENT        TOTAL
                     HT    DIA    T   DIS   SAMP


PART         19040                         19040                   19040
NOX,SO2       4000                          4000                    4000





















TOTAL        23040    0     0     0    0   23040       0  0        23040
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CONTINUOUS EMISSION MONITORING SYSTEM COSTS

INDUSTRY	INORGANIC CHEMICALS:AMMONIUM NITRATE
SIC	3711
# OF SOURCES/PLANT	1
ANALYSER TYPE	OPACITY
GAS TEMP	MED
COMMENTS	STACK LADDER/PLATFORM RETEROFIT @ $15000 EACH STACK

COSTS OF INSTRUMENTS TO BE USED & TYPE(E/I)

INSTRUMENT	COST/UNIT	EXTRACTIVE 1/0	INSITU 1/0	TOTAL
OPACITY	25000	0	1	25000
SO2	20000	0	0	0
NOx	15000	0	0	0
O2	6000	0	0	0
CO2	7000	0	0	0
CO	7000	0	0	0
TRS	25000	0	0	0
OTHER	70000	0	0	0
		0	1	25000

FACTORED COST ESTIMATE

NUMBER OF SOURCES	1
NUMBER OF PARAMETERS	1

STACK GAS CONDITIONS

		LOW	MEDIUM	HIGH	FACTOR
TEMPERATURE	1/0	0	1	0	1
CORROSIVITY	1/0	0	1	0	1
DUST LOADING	1/0	0	1	0	1

	TOTAL COST	BASE COST
INSTRUMENT COST	25000	
SAMPLE CONDITIONING	0	70000
DATA ACQUISITION COST	5000	5000
INSTALLATION COST	5000	5000
RETROFIT COST	15000	15000
CERTIFICATION COST	11000	9000
COMMISSIONING COST	5000	5000
	------	------
TOTAL INSTALLATION & COMMISSION	66000	109000
AUDITING COST	4000	4000
MAINTENANCE COST	6400	400
DATA PROCESSING COST	6000	750
	------	------
TOTAL ANNUAL OPERATING COSTS	16400	5150

CONTINUOUS EMISSION MONITORING SYSTEM COSTS

INDUSTRY	INORGANIC CHEMICALS:NITRIC ACID
SIC	3711
# OF SOURCES/PLANT	1
ANALYSER TYPE	OPACITY,NOX,O2
GAS TEMP	MED
COMMENTS	STACK LADDER/PLATFORM RETEROFIT @ $50000 EACH STACK

COSTS OF INSTRUMENTS TO BE USED & TYPE(E/I)

INSTRUMENT	COST/UNIT	EXTRACTIVE 1/0	INSITU 1/0	TOTAL
OPACITY	25000	0	1	25000
SO2	20000	0	0	0
NOx	15000	1	0	15000
O2	6000	1	0	6000
CO2	7000	0	0	0
CO	7000	0	0	0
TRS	25000	0	0	0
OTHER	70000	0	0	0
		2	1	46000

FACTORED COST ESTIMATE

NUMBER OF SOURCES	1
NUMBER OF PARAMETERS	3

STACK GAS CONDITIONS

		LOW	MEDIUM	HIGH	FACTOR
TEMPERATURE	1/0	0	1	0	1
CORROSIVITY	1/0	0	0	1	1.5
DUST LOADING	1/0	0	1	0	1

	TOTAL COST	BASE COST
INSTRUMENT COST	46000	
SAMPLE CONDITIONING	105000	70000
DATA ACQUISITION COST	12000	10000
INSTALLATION COST	10000	5000
RETROFIT COST	50000	50000
CERTIFICATION COST	11400	9000
COMMISSIONING COST	12000	5000
	------	------
TOTAL INSTALLATION & COMMISSION	246400	149000
AUDITING COST	4800	4000
MAINTENANCE COST	41400	400
DATA PROCESSING COST	8400	750
	------	------
TOTAL ANNUAL OPERATING COSTS	54600	5150

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CONTINUOUS EMISSION MONITORING SYSTEM COSTS

INDUSTRY                 INORGANIC CHEMICALS:AMMONIA
SIC                            3711
# OF SOURCES/PLANT               1
ANALYSER TYPE            OPACITY,NOX,SO2,O2
GAS TEMP                 MED
COMMENTS                 STACK LADDER/PLATFORM RETEROFIT
                         @ $50000 EACH STACK
COSTS OF INSTRUMENTS TO BE USED & TYPE(E/I)

INSTRUMENT  COST/UNIT EXTRACTIVE   INSITU    TOTAL
                             1/0      1/0
OPACITY         25000          0        1    25000
SO2             20000          1        0    20000
NOx             15000          1        0    15000
O2               6000          1        0     6000
CO2              7000          0        0        0
CO               7000          0        0        0
TRS             25000          0        0        0
OTHER           70000          0        0        0

                               3        1    66000

FACTORED COST ESTIMATE
NUMBER OF SOURCES                       1
NUMBER OF PARAMETERS                    4

STACK GAS CONDITIONS
                          LOW    MEDIUM      HIGH   FACTOR
TEMPERATURE   1/0           0         1         0        1
CORROSIVITY   1/0           0         1         0        1
DUST LOADING  1/0           0         1         0        1
                            TOTAL COST          BASE COST

INSTRUMENT COST                  66000
SAMPLE CONDITIONING              70000              70000
DATA ACQUISITION COST            13000              10000
INSTALLATION COST                10000               5000
RETROFIT COST                    50000              50000
CERTIFICATION COST               11600               9000
COMMISSIONING COST                9500               5000
                                ------             ------
TOTAL INSTALLATION & COMMISSION 230100             149000

AUDITING COST                     5200               4000
MAINTENANCE COST                 33600                400
DATA PROCESSING COST              9600                750
                                ------             ------
TOTAL ANNUAL OPERATING COSTS     48400               5150
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CONTINUOUS EMISSION MONITORING SYSTEM COSTS

INDUSTRY	PETROLEUM REFINERIES:HEATERS/BOILERS
SIC	3611
# OF SOURCES/PLANT	6
ANALYSER TYPE	SO2,NOX,O2
GAS TEMP	MED
COMMENTS	STACK LADDER/PLATFORM RETEROFIT @ $100000 EACH STACK

COSTS OF INSTRUMENTS TO BE USED & TYPE(E/I)

INSTRUMENT	COST/UNIT	EXTRACTIVE 1/0	INSITU 1/0	TOTAL
OPACITY	25000	0	0	0
SO2	20000	1	0	20000
NOx	15000	1	0	15000
O2	6000	1	0	6000
CO2	7000	0	0	0
CO	7000	0	0	0
TRS	25000	0	0	0
OTHER	0	0	0	0
		3	0	41000

FACTORED COST ESTIMATE

NUMBER OF SOURCES	6
NUMBER OF PARAMETERS	3

STACK GAS CONDITIONS

		LOW	MEDIUM	HIGH	FACTOR
TEMPERATURE	1/0	0	1	0	1
CORROSIVITY	1/0	0	1	0	1
DUST LOADING	1/0	0	1	0	1

	TOTAL COST	BASE COST
INSTRUMENT COST	41000	
SAMPLE CONDITIONING	140000	70000
DATA ACQUISITION COST	17000	10000
INSTALLATION COST	12500	5000
RETROFIT COST	600000	100000
CERTIFICATION COST	17400	9000
COMMISSIONING COST	16000	5000
	------	------
TOTAL INSTALLATION & COMMISSION	843900	199000
AUDITING COST	16800	4000
MAINTENANCE COST	40800	400
DATA PROCESSING COST	29400	750
	------	------
TOTAL ANNUAL OPERATING COSTS	87000	5150

CONTINUOUS EMISSION MONITORING SYSTEM COSTS

INDUSTRY	PETROLEUM REFINERIES:FCCU
SIC	3611
# OF SOURCES/PLANT	2
ANALYSER TYPE	SO2,NOX,O2,OPACITY
GAS TEMP	MED
COMMENTS	STACK LADDER/PLATFORM RETEROFIT @ $150000 EACH STACK

COSTS OF INSTRUMENTS TO BE USED & TYPE(E/I)

INSTRUMENT	COST/UNIT	EXTRACTIVE 1/0	INSITU 1/0	TOTAL
OPACITY	25000	0	1	50000
SO2	20000	1	0	20000
NOx	15000	1	0	15000
O2	6000	1	0	6000
CO2	7000	0	0	0
CO	7000	0	0	0
TRS	25000	0	0	0
OTHER	0	0	0	0
		3	1	91000

FACTORED COST ESTIMATE

NUMBER OF SOURCES 2

NUMBER OF PARAMETERS 4

STACK GAS CONDITIONS

		LOW	MEDIUM	HIGH	FACTOR
TEMPERATURE	1/0	0	1	0	1
CORROSIVITY	1/0	0	1	0	1
DUST LOADING	1/0	0	1	0	1

	TOTAL COST	BASE COST
INSTRUMENT COST	91000	
SAMPLE CONDITIONING	84000	70000
DATA ACQUISITION COST	14000	10000
INSTALLATION COST	16500	5000
RETROFIT COST	300000	150000
CERTIFICATION COST	12900	9000
COMMISSIONING COST	11400	5000
	------	------
TOTAL INSTALLATION & COMMISSION	529800	249000
AUDITING COST	7800	4000
MAINTENANCE COST	42720	400
DATA PROCESSING COST	14400	750
	------	------
TOTAL ANNUAL OPERATING COSTS	64920	5150

CONTINUOUS EMISSION MONITORING SYSTEM COSTS

INDUSTRY	PETROLEUM REFINERIES:SULPHUR PLANT
SIC	3611
# OF SOURCES/PLANT	1
ANALYSER TYPE	SO2,O2
GAS TEMP	MED
COMMENTS	STACK LADDER/PLATFORM RETEROFIT @ $150000 EACH STACK

COSTS OF INSTRUMENTS TO BE USED & TYPE(E/I)

INSTRUMENT	COST/UNIT	EXTRACTIVE 1/0	INSITU 1/0	TOTAL
OPACITY	25000	0	0	0
SO2	20000	1	0	20000
NOx	15000	0	0	0
O2	6000	1	0	6000
CO2	7000	0	0	0
CO	7000	0	0	0
TRS	25000	0	0	0
OTHER	0	0	0	0
		2	0	26000

FACTORED COST ESTIMATE

NUMBER OF SOURCES	1
NUMBER OF PARAMETERS	2

STACK GAS CONDITIONS

		LOW	MEDIUM	HIGH	FACTOR
TEMPERATURE	1/0	0	1	0	1
CORROSIVITY	1/0	0	1	0	1
DUST LOADING	1/0	0	1	0	1

	TOTAL COST	BASE COST
INSTRUMENT COST	26000	
SAMPLE CONDITIONING	70000	70000
DATA ACQUISITION COST	11000	10000
INSTALLATION COST	5000	5000
RETROFIT COST	150000	150000
CERTIFICATION COST	11200	9000
COMMISSIONING COST	6500	5000
	------	------
TOTAL INSTALLATION & COMMISSION	279700	249000
AUDITING COST	4400	4000
MAINTENANCE COST	21200	400
DATA PROCESSING COST	7200	750
	------	------
TOTAL ANNUAL OPERATING COSTS	32800	5150

MONITORING COSTS

STACK SAMPLING
COST CALCULATION SHEET

INDUSTRY: PETROLEUM REFINERIES
SIC: 3611

LOCATION: SARNIA AREA

COST BASIS: PER PLANT
6 STACKS-HEATERS/BOILERS S02,NOX,VO
TRACE ORG
2 STACKS-FCCU PART,S02,NOX,VOC
TRACE ORG,METALS
1 STACK-SULPHUR PLANT S02

CONTAMINANT	SAMPLING						ANALYSIS	TOTAL
	BASE	ADJUSTMENT				TOTAL SAMP		
		HT	DIA	T	DIS			
PARTICULATE	13020	600	900		400	14920		14920
METALS							2120	2120
MM5	66690	3200	7600		600	78090	160000	238090
VOST	32350	800	800		400	34350	40000	74350
S02,NOX	27100	1200	800		400	29500		29500
S02	2800				400	3200		3200
TOTAL	141960	5800	*****	0	2200	160060	202120	362180

NOTE: HT -HEIGHT
DIA -DIAMETER
T -TEMPERATURE
DIS -DISTANCE

CONTINUOUS EMISSION MONITORING SYSTEM COSTS

INDUSTRY	ASPHALT PAVING
SIC	3699
# OF SOURCES/PLANT	1
ANALYSER TYPE	OPACITY
GAS TEMP	MED
COMMENTS	STACK LADDER/PLATFORM RETEROFIT @ $5000 EACH STACK

COSTS OF INSTRUMENTS TO BE USED & TYPE(E/I)

INSTRUMENT	COST/UNIT	EXTRACTIVE 1/0	INSITU 1/0	TOTAL
OPACITY	25000	0	1	25000
SO2	20000	0	0	0
NOx	15000	0	0	0
O2	6000	0	0	0
CO2	7000	0	0	0
CO	7000	0	0	0
TRS	25000	0	0	0
OTHER	70000	0	0	0
		0	1	25000

FACTORED COST ESTIMATE

NUMBER OF SOURCES	1
NUMBER OF PARAMETERS	1

STACK GAS CONDITIONS

		LOW	MEDIUM	HIGH	FACTOR
TEMPERATURE	1/0	0	1	0	1
CORROSIVITY	1/0	0	1	0	1
DUST LOADING	1/0	0	1	0	1

	TOTAL COST	BASE COST
INSTRUMENT COST	25000	
SAMPLE CONDITIONING	0	70000
DATA ACQUISITION COST	5000	5000
INSTALLATION COST	5000	5000
RETROFIT COST	5000	5000
CERTIFICATION COST	11000	9000
COMMISSIONING COST	5000	5000
	------	------
TOTAL INSTALLATION & COMMISSION	56000	99000
AUDITING COST	4000	4000
MAINTENANCE COST	6400	400
DATA PROCESSING COST	6000	750
	------	------
TOTAL ANNUAL OPERATING COSTS	16400	5150

MONITORING COSTS

STACK SAMPLING
COST CALCULATION SHEET

INDUSTRY:	ASPHALT PAVING
SIC:	3699
LOCATION:	TORONTO AREA
COST BASIS:	PER PLANT 1 STACK PART

CONTAMINANT	SAMPLING						ANALYSIS	TOTAL
	BASE	ADJUSTMENT				TOTAL		
		HT	DIA	T	DIS	SAMP		
PARTICULATE	7000					7000		7000
TOTAL	7000	0	0	0	0	7000	0	7000

NOTE: HT -HEIGHT
DIA -DIAMETER
T -TEMPERATURE
DIS -DISTANCE

MONITORING COSTS

STACK SAMPLING
COST CALCULATION SHEET

INDUSTRY: INORGANIC CHEMICAL
SIC: 3711

LOCATION: TORONTO AREA
COST BASIS: PER SITE

CONTAMINANT	SAMPLING						ANALYSIS	TOTAL
	BASE	ADJUSTMENT				TOTAL		
		HT	DIA	T	DIS	SAMP		
AMMONIA PRODUCTS								
1 STACK	11500					11500	1360	12860
PART,SO2,NOX THC,NH3,F, METALS								
AMMONIUM PHOSPHATE								
1 STACK	11000					11000		11000
PART,NOX,THC								
SODIUM CRBONATE								
1 STACK								
PART	7000					7000		7000
UREA&CARBON PRODUCTS								
1 STACK								
PART,	7000					7000		7000
NOX,SO2,THC	4500					4500		4500
NH3							300	300
PHOSPHORIC ACID								
1 STACK								
PART	7000					7000		7000
THC	3500					3500		3500
F							300	300
CARBON PELLETS								
1 STACK								
VOST	4700					4700	5000	9700
NIRIC ACID								
1 STACK								
PART	7000					7000		7000
NOX,THC	4000					4000		4000
AMMONIUM NITRATE								
1 STACK								

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PART            7000                         7000                 7000
NITRIC ACID,NH3                                        240         240
THC             3500                         3500                 3500
TOTAL          67200    0    0    0    0    67200     6960       74160


NOTE:HT     -HEIGHT
     DIA    -DIAMETER
     T      -TEMPERATURE
     DIS    -DISTANCE
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CONTINUOUS EMISSION MONITORING SYSTEM COSTS

INDUSTRY	INDUSTRIAL ORGANIC
SIC	3712
# OF SOURCES/PLANT	1
ANALYSER TYPE	NOX,O2
GAS TEMP	MED
COMMENTS	STACK LADDER/PLATFORM RETEROFIT @ $15000 EACH STACK

COSTS OF INSTRUMENTS TO BE USED & TYPE(E/I)

INSTRUMENT	COST/UNIT	EXTRACTIVE 1/0	INSITU 1/0	TOTAL
OPACITY	25000	0	0	0
SO2	20000	0	0	0
NOx	15000	1	0	15000
O2	6000	1	0	6000
CO2	7000	0	0	0
CO	7000	0	0	0
TRS	25000	0	0	0
OTHER	0	0	0	0
		2	0	21000

FACTORED COST ESTIMATE

NUMBER OF SOURCES	5
NUMBER OF PARAMETERS	2

STACK GAS CONDITIONS

		LOW	MEDIUM	HIGH	FACTOR
TEMPERATURE	1/0	0	1	0	1
CORROSIVITY	1/0	0	1	0	1
DUST LOADING	1/0	0	1	0	1

	TOTAL COST	BASE COST
INSTRUMENT COST	21000	
SAMPLE CONDITIONING	126000	70000
DATA ACQUISITION COST	15000	10000
INSTALLATION COST	11000	5000
RETROFIT COST	75000	15000
CERTIFICATION COST	15600	9000
COMMISSIONING COST	11700	5000
	------	------
TOTAL INSTALLATION & COMMISSION	275300	114000
AUDITING COST	13200	4000
MAINTENANCE COST	29680	400
DATA PROCESSING COST	21600	750
	------	------
TOTAL ANNUAL OPERATING COSTS	64480	5150

```
CONTINUOUS EMISSION MONITORING SYSTEM COSTS

INDUSTRY                INDUSTRIAL ORGANIC
SIC                              3712
# OF SOURCES/PLANT                  1
ANALYSER TYPE           NOX,O2,HCL
GAS TEMP                MED
COMMENTS                STACK LADDER/PLATFORM RETEROFIT
                        @ $15000 EACH STACK
COSTS OF INSTRUMENTS TO BE USED & TYPE(E/I)

INSTRUMENT  COST/UNIT EXTRACTIVE    INSITU     TOTAL
                             1/0       1/0
OPACITY         25000          0         0         0
SO2             20000          0         0         0
NOx             15000          1         0     15000
O2               6000          1         0      6000
CO2              7000          0         0         0
CO               7000          0         0         0
TRS             25000          0         0         0
OTHER           70000          1         0     70000

                               3         0     91000


FACTORED COST ESTIMATE
NUMBER OF SOURCES                        5
NUMBER OF PARAMETERS                     3

STACK GAS CONDITIONS
                             LOW    MEDIUM      HIGH    FACTOR
TEMPERATURE     1/0            0         1         0         1
CORROSIVITY     1/0            0         1         0         1
DUST LOADING    1/0            0         1         0         1

                                TOTAL COST          BASE COST

INSTRUMENT COST                      91000
SAMPLE CONDITIONING                 126000              70000
DATA ACQUISITION COST                16000              10000
INSTALLATION COST                    11000               5000
RETROFIT COST                        75000              15000
CERTIFICATION COST                   16200               9000
COMMISSIONING COST                   14400               5000
                                    ------             ------
TOTAL INSTALLATION & COMMISSION     349600             114000

AUDITING COST                        14400               4000
MAINTENANCE COST                     38080                400
DATA PROCESSING COST                 25200                750
                                    ------             ------
TOTAL ANNUAL OPERATING COSTS         77680               5150
```

MONITORING COSTS

STACK SAMPLING
COST CALCULATION SHEET

INDUSTRY: INDUSTRIAL ORGANIC
SIC: 3712

LOCATION: SARNIA

COST BASIS: INDIVIDUAL PLANTS
COMPANY - INORGANIC A
4 STACKS POLYEHTYLENE,VINYL CHLORID
ETHYLENE OXIDE
COMPANY - INORGANIC B
5 STACKS VOC,NOX
8 STACKS VOC
COMPANY INORGANIC C
1 STACK VOC,NOX
COMPANY INORGANIC D
12 STACKS VOC,NOX
28 STACKS VOC
COMPANY INORGANIC E
1 STACK NOX,HCL, FLOROCARBON
5 STACKS PEROXIDE,VOC
4 STACKS POWER BOILER,PART,METALS

CONTAMINANT	SAMPLING						ANALYSIS	TOTAL
	BASE	ADJUSTMENT				TOTAL		
		HT	DIA	T	DIS	SAMP		
COMPANY A								
VOST,NOX	22853				400	23253	20000	43253
COMPANY B								
VOST	52100				400	52500	500013	552513
NOX	14700					14700		14700
COMPANY C								
VOST,NOX	8200				400	8600	5000	13600
COMPANY D								
VOST	158750				400	159150	200000	359150
NOX	34300					34300		34300
COMPANY E								
NOX,HCL, FLOROCARBON	10500				400	10900	420	11320
M5,VOST	51580				400	51980	25000	76980
PARTCULATE,	25060				400	25460		25460
METALS						0	4240	4240

```
TOTAL             378043     0      0      0 2800     380843    754673       1135516


NOTE:HT        -HEIGHT
     DIA       -DIAMETER
     T         -TEMPERATURE
     DIS       -DISTANCE
```

MONITORING COSTS

STACK SAMPLING
COST CALCULATION SHEET

INDUSTRY: PLASTIC&SYNTHETIC RESIN
SIC:

LOCATION: TORONTO AREA
COST BASIS: PER PLANT
2 STACKS,STYRENE,VOC

CONTAMINANT	SAMPLING						ANALYSIS	TOTAL
	BASE	ADJUSTMENT				TOTAL		
		HT	DIA	T	DIS	SAMP		
VOST	8650					8650	10000	18650
TOTAL	8650	0	0	0	0	8650	10000	18650

NOTE: HT -HEIGHT
DIA -DIAMETER
T -TEMPERATURE
DIS -DISTANCE ,

CONTINUOUS EMISSION MONITORING SYSTEM COSTS

INDUSTRY	PAINT VARNISH
SIC	3751
# OF SOURCES/PLANT	2
ANALYSER TYPE	OPACITY
GAS TEMP	MED
COMMENTS	STACK LADDER/PLATFORM RETEROFIT @ $5000 EACH STACK

COSTS OF INSTRUMENTS TO BE USED & TYPE(E/I)

INSTRUMENT	COST/UNIT	EXTRACTIVE 1/0	INSITU 1/0	TOTAL
OPACITY	25000	0	1	50000
SO2	20000	0	0	0
NOx	15000	0	0	0
O2	6000	0	0	0
CO2	7000	0	0	0
CO	7000	0	0	0
TRS	25000	0	0	0
OTHER	70000	0	0	0
		0	1	50000

FACTORED COST ESTIMATE

NUMBER OF SOURCES	2
NUMBER OF PARAMETERS	1

STACK GAS CONDITIONS

		LOW	MEDIUM	HIGH	FACTOR
TEMPERATURE	1/0	1	0	0	0.7
CORROSIVITY	1/0	1	0	0	0.7
DUST LOADING	1/0	1	0	0	0.7

	TOTAL COST	BASE COST
INSTRUMENT COST	50000	
SAMPLE CONDITIONING	0	70000
DATA ACQUISITION COST	5500	5000
INSTALLATION COST	10000	5000
RETROFIT COST	10000	5000
CERTIFICATION COST	12000	9000
COMMISSIONING COST	4200	5000
	------	------
TOTAL INSTALLATION & COMMISSION	91700	99000
AUDITING COST	6000	4000
MAINTENANCE COST	8960	400
DATA PROCESSING COST	9000	750
	------	------
TOTAL ANNUAL OPERATING COSTS	23960	5150

MONITORING COSTS

STACK SAMPLING
COST CALCULATION SHEET

INDUSTRY: PAINT & VARNISH
SIC: 3751

LOCATION: TORONTO AREA
COST BASIS: PER SITE
2 STACKS PART
2 STACKS VOC

CONTAMINANT	SAMPLING						ANALYSIS	TOTAL
	BASE	ADJUSTMENT				TOTAL SAMP		
		HT	DIA	T	DIS			
PART	13020					13020		13020
VOST	8650					8650	10000	18650
TOTAL	21670	0	0	0	0	21670	10000	31670

NOTE: HT -HEIGHT
DIA -DIAMETER
T -TEMPERATURE
DIS -DISTANCE

MONITORING COSTS

STACK SAMPLING
COST CALCULATION SHEET

INDUSTRY: DRY CLEANING
SIC:

LOCATION: TORONTO AREA
COST BASIS: PER SITE
1 STACK, PERCHLORETHYLENE

CONTAMINANT	SAMPLING						ANALYSIS	TOTAL
	BASE	ADJUSTMENT				TOTAL SAMP		
		HT	DIA	T	DIS			
VOST	4700					4700	300	5000
TOTAL	4700	0	0	0	0	4700	300	5000

NOTE: HT -HEIGHT
DIA -DIAMETER
T -TEMPERATURE
DIS -DISTANCE

CONTINUOUS EMISSION MONITORING SYSTEM COSTS

INDUSTRY	POWER GENERATION
SIC	
# OF SOURCES/PLANT	4
ANALYSER TYPE	OPACITY,SO2,NOX,O2
GAS TEMP	MED
COMMENTS	RETEROFIT STACK LADDER\PLATFORM

COSTS OF INSTRUMENTS TO BE USED & TYPE(E/I)

INSTRUMENT	COST/UNIT	EXTRACTIVE 1/0	INSITU 1/0	TOTAL
OPACITY	25000	0	1	100000
SO2	20000	1	0	20000
NOx	15000	1	0	15000
O2	6000	1	0	6000
CO2	7000	0	0	0
CO	7000	0	0	0
TRS	25000	0	0	0
OTHER	0	0	0	0
		3	1	141000

FACTORED COST ESTIMATE

NUMBER OF SOURCES	4
NUMBER OF PARAMETERS	4

STACK GAS CONDITIONS

		LOW	MEDIUM	HIGH	FACTOR
TEMPERATURE	1/0	0	1	0	1
CORROSIVITY	1/0	0	1	0	1
DUST LOADING	1/0	0	1	0	1

	TOTAL COST	BASE COST
INSTRUMENT COST	141000	
SAMPLE CONDITIONING	112000	70000
DATA ACQUISITION COST	16000	10000
INSTALLATION COST	29500	5000
RETROFIT COST	600000	150000
CERTIFICATION COST	15500	9000
COMMISSIONING COST	15200	5000
	------	------
TOTAL INSTALLATION & COMMISSION	929200	249000
AUDITING COST	13000	4000
MAINTENANCE COST	60960	400
DATA PROCESSING COST	24000	750
	------	------
TOTAL ANNUAL OPERATING COSTS	97960	5150

```
                           MONITORING COSTS
                           ----------------

                            STACK SAMPLING
                         COST CALCULATION SHEET

                    INDUSTRY:       POWER GENERATION
                    SIC:

                    LOCATION:

                    COST BASIS:     INDIVIDUAL STATIONS
                                    8 UNITS PART,METALS,TR ORG,SO2,NOX
======================================================================
CONTAMINANT             SAMPLING                  ANALYSIS     TOTAL
======================================================================
              BASE         ADJUSTMENT          TOTAL
                     HT    DIA   T   DIS       SAMP

PARTICULATE    49140 4800 7600                  61540               61540
METALS                                                     8480      8480

MM5            66690 5600 7600                  79890    160000    239890


SO2,NOX        27100 2400 1600                  31100               31100












TOTAL         142930 **********   0    0     172530    168480    341010


NOTE:HT      -HEIGHT
     DIA     -DIAMETER
     T       -TEMPERATURE
     DIS     -DISTANCE
```

```
CONTINUOUS EMISSION MONITORING SYSTEM COSTS

INDUSTRY                    SEWAGE SLUDGE INCINERATORS
SIC
# OF SOURCES/PLANT                     1
ANALYSER TYPE               OPACITY,NOX,SO2,CO,O2,HCL
GAS TEMP                    MED
COMMENTS                    STACK LADDER/PLATFORM RETEROFIT
                            @ $50000 EACH STACK
COSTS OF INSTRUMENTS TO BE USED & TYPE(E/I)

INSTRUMENT  COST/UNIT EXTRACTIVE    INSITU     TOTAL
                             1/0       1/0
OPACITY         25000          0         1     25000
SO2             20000          1         0     20000
NOx             15000          1         0     15000
O2               6000          1         0      6000
CO2              7000          0         0         0
CO               7000          1         0      7000
TRS             25000          0         0         0
OTHER           70000          1         0     70000

                               5         1    143000

FACTORED COST ESTIMATE
NUMBER OF SOURCES                        1
NUMBER OF PARAMETERS                     6

STACK GAS CONDITIONS
                             LOW    MEDIUM      HIGH    FACTOR
TEMPERATURE    1/0             0         1         0         1
CORROSIVITY    1/0             0         1         0         1
DUST LOADING   1/0             0         1         0         1

                                TOTAL COST          BASE COST

INSTRUMENT COST                     143000
SAMPLE CONDITIONING                  70000              70000
DATA ACQUISITION COST                15000              10000
INSTALLATION COST                    10000               5000
RETROFIT COST                        50000              50000
CERTIFICATION COST                   12000               9000
COMMISSIONING COST                   12500               5000
                                    ------             ------
TOTAL INSTALLATION & COMMISSION     312500             149000

AUDITING COST                         6000               4000
MAINTENANCE COST                     45600                400
DATA PROCESSING COST                 12000                750
                                    ------             ------
TOTAL ANNUAL OPERATING COSTS         63600               5150
```

MONITORING COSTS

STACK SAMPLING
COST CALCULATION SHEET

INDUSTRY: SEWAGE SLUDGE INCINERATION
SIC:
LOCATION: TORONTO

COST BASIS: PER PLANT
1 STACK PART,METALS,HCL,TR ORG
SO2,NOX,THC,CO

CONTAMINANT	SAMPLING						ANALYSIS	TOTAL
	BASE	ADJUSTMENT HT	DIA	T	DIS	TOTAL SAMP		
PARTICULATE	7000	300	450			7750		7750
METALS							1060	1060
HCL							120	120
MM5	9500	400	950			10850	20000	30850
SO2,NOX,CO THC	5000	250	100			5350		5350
TOTAL	21500	950	1500	0	0	23950	21180	45130

NOTE: HT -HEIGHT
DIA -DIAMETER
T -TEMPERATURE
DIS -DISTANCE

CONTINUOUS EMISSION MONITORING SYSTEM COSTS

INDUSTRY	MUNCIPLE INCINERATORS
SIC	4999
# OF SOURCES/PLANT	2
ANALYSER TYPE	OPACITY,NOX,SO2,CO,O2,HCL
GAS TEMP	MED
COMMENTS	STACK LADDER/PLATFORM RETEROFIT @ $50000 EACH STACK

COSTS OF INSTRUMENTS TO BE USED & TYPE(E/I)

INSTRUMENT	COST/UNIT	EXTRACTIVE 1/0	INSITU 1/0	TOTAL
OPACITY	25000	0	1	50000
SO2	20000	1	0	20000
NOx	15000	1	0	15000
O2	6000	1	0	6000
CO2	7000	0	0	0
CO	7000	1	0	7000
TRS	25000	0	0	0
OTHER	70000	1	0	70000
		5	1	168000

FACTORED COST ESTIMATE

NUMBER OF SOURCES	2
NUMBER OF PARAMETERS	6

STACK GAS CONDITIONS

		LOW	MEDIUM	HIGH	FACTOR
TEMPERATURE	1/0	0	1	0	1
CORROSIVITY	1/0	0	1	0	1
DUST LOADING	1/0	0	1	0	1

	TOTAL COST	BASE COST
INSTRUMENT COST	168000	
SAMPLE CONDITIONING	84000	70000
DATA ACQUISITION COST	16000	10000
INSTALLATION COST	16500	5000
RETROFIT COST	100000	50000
CERTIFICATION COST	13500	9000
COMMISSIONING COST	15000	5000
	------	------
TOTAL INSTALLATION & COMMISSION	413000	149000
AUDITING COST	9000	4000
MAINTENANCE COST	55920	400
DATA PROCESSING COST	18000	750
	------	------
TOTAL ANNUAL OPERATING COSTS	82920	5150

MONITORING COSTS

STACK SAMPLING
COST CALCULATION SHEET

INDUSTRY: MUNICIPAL INCINERATORS
SIC: 4999
LOCATION: HAMILTON/LONDON

COST BASIS: PER PLANT
HAMILTON 2 STACKS
LONDON 1 STACK
PART,METALS,TR ORG,NOX,SO2,HCL,THC

CONTAMINANT	SAMPLING						ANALYSIS	TOTAL
	BASE	ADJUSTMENT				TOTAL SAMP		
		HT	DIA	T	DIS			
LONDON								
PARTICULATE	7000				400	7400		7400
METALS							1060	1060
HCL						0	120	120
MM5	9500				600	10100	20000	30100
SO2,NOX,THC	5000				400	5400		5400
THC								
HAMILTON								
PARTICULATE	6020				400	6420		6420
METALS							2120	2120
HCL						0	240	240
MM5	17670				600	18270	40000	58270
SO2,NOX,THC	9100				400	9500		9500
THC								
TOTAL	54290	0	0	0	2800	57090	63540	120630

NOTE: HT -HEIGHT
DIA -DIAMETER
T -TEMPERATURE
DIS -DISTANCE

CONTINUOUS EMISSION MONITORING SYSTEM COSTS

INDUSTRY	TRANSFER STATION
SIC	4999
# OF SOURCES/PLANT	1
ANALYSER TYPE	OPACITY
GAS TEMP	LOW
COMMENTS	STACK LADDER/PLATFORM RETEROFIT @ $5000 EACH STACK

COSTS OF INSTRUMENTS TO BE USED & TYPE(E/I)

INSTRUMENT	COST/UNIT	EXTRACTIVE 1/0	INSITU 1/0	TOTAL
OPACITY	25000	0	1	25000
SO2	20000	0	0	0
NOx	15000	0	0	0
O2	6000	0	0	0
CO2	7000	0	0	0
CO	7000	0	0	0
TRS	25000	0	0	0
OTHER	70000	0	0	0
		0	1	25000

FACTORED COST ESTIMATE

NUMBER OF SOURCES	1
NUMBER OF PARAMETERS	1

STACK GAS CONDITIONS

		LOW	MEDIUM	HIGH	FACTOR
TEMPERATURE	1/0	1	0	0	0.7
CORROSIVITY	1/0	1	0	0	0.7
DUST LOADING	1/0	1	0	0	0.7

	TOTAL COST	BASE COST
INSTRUMENT COST	25000	
SAMPLE CONDITIONING	0	70000
DATA ACQUISITION COST	5000	5000
INSTALLATION COST	5000	5000
RETROFIT COST	5000	5000
CERTIFICATION COST	11000	9000
COMMISSIONING COST	3500	5000
	------	------
TOTAL INSTALLATION & COMMISSION	54500	99000
AUDITING COST	4000	4000
MAINTENANCE COST	4480	400
DATA PROCESSING COST	6000	750
	------	------
TOTAL ANNUAL OPERATING COSTS	14480	5150

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                                MONITORING COSTS
                                ----------------

                                STACK SAMPLING
                             COST CALCULATION SHEET

                     INDUSTRY:          TRANSFER STATION
                     SIC:               4999

                     LOCATION:          TORONTO AREA
                     COST BASIS:        PER SITE
                                        1 STACK PART,VOC
=================================================================================
CONTAMINANT                  SAMPLING                        ANALYSIS      TOTAL
=================================================================================
                   BASE          ADJUSTMENT          TOTAL
                          HT     DIA    T     DIS    SAMP


PART               7000                               7000                  7000
VOST               4700                               4700      5000        9700



















TOTAL             11700    0      0     0      0     11700      5000  0    16700


NOTE:HT        -HEIGHT
```

APPENDIX E

Sampling and Analytical Methods

Appendix E

SAMPLING AND ANALYTICAL METHODS
FOR
PROPOSED REGULATION 308 AMBIENT AIR COMPOUNDS

Nos.	Name of Contaminant	Cdn. Methodology		U.S. Methodology	
		Sampling	Analytical	Sampling	Analytical
1	Acetic Acid			NIOSH 1603	GC/FID
2	Acetone			NIOSH 1300	GC/FID
				TO-5	HPLC/UV
3	Acetylene	MOE	GC/FID	WHOLE	GC
4	Acrylamide			NIOSH 247	GC/FID
5	Acrylonitrile			NIOSH 1604	GC/FID
				TO-3	GC/ECD
				TO-2	GC/MS
6	N-Alkyltoluene Sulphonamide			NS	
7	Alpha Napthol			OSHA N605	HPLC
8	Aluminum Oxide			OSHA 0160	AAS
9	Ammonia			NIOSH 6701	
10	Ammonium Chloride			OSHA 0175	NVM
11	Antimony			NIOSH 7300	ICP
12	Arsenic	MOE	AAS	NIOSH 7900	ICP
				NIOSH 7300	ICP
13	Arsine			NIOSH 6001	AAS
14	Asbestos (fibers of length greater than 5 micrometers)			EPA	ELECT MICRO
15	Asbestos (total)			NIOSH 7402	
16	Barium - total water soluble			NIOSH 5198	AAS
17	Benzene	MOE	GC/FID	TO-1	GC/MS
				TO-14	CG/MS
				NIOSH 3700	GC/PID

Appendix E (continued)

		Cdn. Methodology		U.S. Methodology	
Nos.	Name of Contaminant	Sampling	Analytical	Sampling	Analytical
18	Benzo(a)pyrene (single source)	EPS	GC/MS	APHA 102	TLC
				TO-13	HPLC
				NIOSH 5506	HPLC
				NIOSH 5516	GC
	Benzo(a)pyrene (all sources)	EPS	GC/MS	APHA 102	TLC
				TO-13	HPLC
				NIOSH 5506	HPLC
				NIOSH 5516	GC
19	Benzothiazole			OSHA B506	NVM
20	Benzoyl Chloride			NIOSH 1003	
				TO-14	GC/MS
21	Beryllium			NIOSH 7300	ICP
22	Biphenyl			NIOSH 2530	GC/FID
23	Boron			OSHA B142	ICP
24	Boron Tribromide			OSHA B0381	SPEC ION ELE
25	Boron Trichloride			NS	SPEC ION ELE
26	Boron Trifluoride			OSHA B0382	SPEC ION ELE
27	Bromacil			NS	
28	Bromine			OSHA B708	NVM
29	N-Butanol			OSHA B0390	IC
30	2-Butanone (MEK)			NIOSH 2500	GC/FID
				TO-1	GC/MS
31	N-Butyl Acetate			NIOSH 1450	GC/FID
32	Butyl Stearate			OSHA B706	NVM
33	Cadmium	MOE	AAS	NIOSH 7300	ICP
34	Calcium Carbide			NS	
35	Calcium Cyanide (as total salt)			NS	
36	Calcium Oxide			NS	

Appendix E (continued)

Nos.	Name of Contaminant	Cdn. Methodology Sampling	Cdn. Methodology Analytical	U.S. Methodology Sampling	U.S. Methodology Analytical
37	Captan			NIOSH S205	AAS
				TO-10	GC/ECD
38	Carbon Black			OSHA B0529	HPLC-UV
39	Carbon Disulphide			NIOSH 1600	GC/FPD
				TO-1	GC/MS
40	Carbon Monoxide	MOE	NDIR	EPA REF	NDIR
		EPS	NDIR		
41	Carbon Tetrachloride	MOE	GC/ECD	NIOSH 1003	GC/FID
				TO-14	GC/MS
				TO-1	GC/MS
42	Chloramben			NS	
43	Chlordane			TO-10	GC/ECD
				TO-4	GC/ECD
44	Chlorinated Dibenzo Dioxins (CDDs)			NIOSH S278	GC/ECCD
				TO-9	HRGC/HRMS
45	Mixtures of Chlorinated Dibenzo Dioxins (CDDs) and Chlorinated Dibenzo Furans (CDFs)			TO-9	HRGC/HRMS
46	Chlorine			NIOSH 209	COLOR
47	Chlorine Dioxide			OSHA 0614	DET TUBE
48	Chlorodifluoromethane			OSHA 0628	DET TUBE
49	Chloroform	MOE	GC/ECD	TO-1	GC/MS
				TO-14	GC/MS
				NIOSH 1003	GC/FID
50	Chromium	MOE	AAS	NIOSH 7300	ICP
51	Chromium (Di, Tri, and Hexavalent forms)			NIOSH 7600	AAS
52	Coal Tar Pitch Volatiles			NIOSH 5023	GRAV

Appendix E (continued)

Nos.	Name of Contaminant	Cdn. Methodology		U.S. Methodology	
		Sampling	Analytical	Sampling	Analytical
53	Copper	MOE	AAS	NIOSH 7300	ICP
54	Cresols			NIOSH 2001	GC/FID
				TO-8	HPLC
55	Cyclo Sol 63			NS	
56	Cyclohexane	MOE	GC/FID	NIOSH 1500	GC/FID
57	2,2-Dichloropropionic Acid			NS	
58	Decaborane			OSHA 0853	
59	1-Decene	MOE	GC/FID	NS	
60	Diazinon			OSHA 62	GC/FID
61	Diborane			OSHA 0862	AAS
				NIOSH 6006	
62	Dibutyltin Dilaurate			NIOSH 5504	
63	Dicapryl Phthalate			NS	
64	1,1-Dichloroethene			TO-2	GC/MS
				NIOSH 1005	
65	Difluorodichloromethane			NIOSH 2516	GC/FID
66	Diiisobutyl			NIOSH 1300	GC/FID
67	N,N,Dimethyl-1,3-Diaminopropane			NS	
68	Dimethyl Disulphide			WHOLE	GC/PID
69	Dimethyl Ether			NS	
70	Dioctyl Phthalate			OSHA 1000	HPLC-UV
				NIOSH 5020	
71	Dioxane			NIOSH 1602	GC
72	Dioxolane			OSHA D655	NVM
73	Dodecyl Benzene Sulphonic Acid			NS	
74	Dodine			NS	

Appendix E (continued)

Nos.	Name of Contaminant	Cdn. Methodology		U.S. Methodology	
		Sampling	Analytical	Sampling	Analytical
75	Droperidol			NS	
76	Dustfall	MOE	GRAV	NIOSH 0500	GRAV
77	Ethanol (ethyl alcohol)	MOE	GC/FID	NIOSH 1400	GC/FID
78	Ethyl Acetate			NIOSH S49	GC
79	Ethyl Acrylate	MOE	GC/FID	NIOSH 1450	GC/FID
80	2-Ethyl Anthraquinone			NS	
81	Ethyl Benzene	MOE	GC/FID	TO-1	GC/MS
				TO-14	GC/MS
				NIOSH 1501	GC/FID
82	Ethyl Ether			NIOSH 1610	
83	Ether-3-Ethoxy Propionate			NS	
84	2-Ethyl Hexanol	MOE	GC/FID	NS	
85	Ethylene	MOE	GC/FID	OSHA 1115	DET TUBE
86	Ethylene-diamine-tetraacetic Acid			OSHA 60	HPLC
87	Ethylene dichloride	MOE	GC/ECD	TO-1	GC/MS
				TO-14	GC/MS
				NIOSH 1003	
88	Ethylene Glycol Butyl Ether (Butyl Cellosolve)			OSHA 07	GC/FID
89	Ethylene Glycol Butyl Ether Acetate (Butyl Cellosolve Acetate)			OSHA 0472	GC/FID
90	Ethylene Glycol Dinitrate			NIOSH 2507	GC/FID
91	Ethylene Glycol Ethyl Ether (Cellosolve)			OSHA 53	GC/FID
92	Ethylene Glycol Ethyl Ether Acetate (Cellosolve Acetate)			NIOSH 5500	
93	Ethylene Oxide			NIOSH 1614	GC/ECD

Appendix E (continued)

Nos.	Name of Contaminant	Cdn. Methodology		U.S. Methodology	
		Sampling	Analytical	Sampling	Analytical
94	Fentanyl Citrate			NS	
95	Ferric Oxide			NS	
96	Fluorides (Gaseous)	MOE	SPEC ION ELEC	NIOSH 7902	SPEC ION ELE
97	Fluorides (Total)	MOE	SPEC ION ELEC	NIOSH 212	SPEC ION ELE
98	Fluorinert 3M-FC-70			NS	
99	Formaldehyde			TO-5	HPLC
				TO-11	HPLC
				NIOSH 2502	GC/FID
100	Formic Acid			NIOSH 232	GC
101	Furfural			NIOSH 2529	HPLC
102	Furfuryl Alcohol			NS	
103	Glutaraldehyde			OSHA 64	HPLC-UV
104	Haloperidol			NS	
105	Hexachlorocyclohexane (Lindane)			NIOSH 5502	GC
106	Hexachlorocyclopentadiene			TO-4	GC/ECD
				TO-10	GC/ECD
				NIOSH 2518	GC/ECD
107	Hexamethyl Disilazane			NS	
108	Hexamethylene Diisocyanate Trimer			OSHA 42	HPLC-UV
109	Hexane	MOE	GC/FID	OSHA S90	GC
				NIOSH 1500	GC/FID
110	Hydrogen Chloride			NIOSH 7903	IC
111	Hydrogen Cyanide			NIOSH 7904	
112	Hydrogen Peroxide			OSHA 1470	COLOUR
113	Hydrogen Sulphide	EPS		NIOSH 296	GC/FPD
114	Iron (metallic)	MOE	AAS	NIOSH 7300	ICP
115	Isobutanol			NIOSH 1401	GC/FID
116	Isobutyl Acetate			OSHA 07	GC/FID
				NIOSH 1450	

Appendix E (continued)

Nos.	Name of Contaminant	Cdn. Methodology		U.S. Methodology	
		Sampling	Analytical	Sampling	Analytical
117	Isopropanol (Isopropyl alcohol)			OSHA 07 NIOSH 1400	GC/FID
118	Isopropyl Acetate			OSHA 07	GC/FID
119	Isopropyl Benzene			NIOSH 1501	GC/FID
120	Lead	EPS MOE	AAS AAS	EPA REF NIOSH 7300	AAS ICP
121	Lead in Dustfall			NIOSH 7300	ICP
122	Lithium			NIOSH 7300	ICP
123	Lithium Hydrides			OSHA 1503	AAS
124	Magnesium Oxide			NIOSH S369	AAS
125	Malathion			NIOSH 5012	GC/FPD
126	Maleic Anhydride			NIOSH 302	AAS
127	Manganese Compounds	EPS MOE	AAS AAS	NIOSH S5	AAS
128	Mercaptans			APHA 118	SPEC - ???
129	Mercapto Benzo Thiazo Disulphide			NS	
130	Mercury			NIOSH 6000	AAS
131	Mercury (alkyl)			NIOSH 1603	NVM
132	Metaldehyde			NS	
133	Methacrylic			NS	
134	Methane Diphenyl Diisocyanate			NS	
135	Methanol (Methyl Alcohol)	MOE	GC/FID	NIOSH 2000	GC/FID
136	Methyl Acrylate			NIOSH S38	GC
137	Methyl Bromide			NIOSH 2520	GC
138	Methyl Chloride	MOE	GC/FID	NIOSH S99	GC
139	Methyl Ethyl Ketone Peroxide			NIOSH 3508	SPEC - ???
140	5-Methyl-2-hexanone			NS	
141	Methyl Isobutyl Ketone			NIOSH 1300	GC/FID
142	Methyl Methacrylate			NIOSH S43	GC

Appendix E (continued)

Nos.	Name of Contaminant	Cdn. Methodology Sampling	Cdn. Methodology Analytical	U.S. Methodology Sampling	U.S. Methodology Analytical
143	Methyl Salicylate			NS	
144	Methoxyclor			NIOSH S321	GC/ECD
145	Methylene Chloride	MOE	GC/ECD	TO-2	GC/MS
				NIOSH 1500	GC/FID
146	4,4-Methylene Bis-2-Chloro-aniline			NIOSH 236	HPLC
147	Methylene Dianiline			OSHA 57	GC
148	Miconazole Nitrate			NS	
149	Milk Powder			NS	
150	Monomethyl Amine			NIOSH 277	GC
151	Naphthalene			TO-4	GC/MS
152	Nickel	MOE	AAS	NIOSH 7300	ICP
153	Nickel Carbonyl			NIOSH S319	SPEC ION ELE
				NIOSH 6007	AAS
154	Nitric Acid			NIOSH 7903	IC
155	Nitrilotriacetic Acid			NIOSH S321	COLOUR
156	Nitrogen Oxides	MOE	CHEM	EPA REF	CHEM
		EPS	CHEM		
				NIOSH 6700	
157	Nitroglycerin			NIOSH 216	GC/ECD
				NIOSH 2507	
158	Nitrous Oxide			NIOSH 6600	IR SPEC
159	Octane	MOE	GC/FID	NIOSH 1500	GC/FID
160	1-Octene			NIOSH 1500	GC/FID
161	Oxalic Acid			OSHA 1970	IC
162	Ozone	MOE	CHEM	EPA REF	CHEM
		EPS	CHEM	NIOSH S8	COLOUR
163	Palladium (H_2O soluble)			NIOSH 1980	DET TUBE
164	Pencillin			OSHA 1986	SPEC - ???
165	Pentaborane			NIOSH S207	HPLC

Appendix E (continued)

Nos.	Name of Contaminant	Cdn. Methodology		U.S. Methodology	
		Sampling	Analytical	Sampling	Analytical
166	Pentachlorophenol			NIOSH S335	GC
				TO-10	GC/ECD
167	Perchloroethylene			TO-1	GC/MS
				TO-14	GC/MS
168	Phenol			TO-8	HPLC
				TO-4	HPLC
				NIOSH 3502	
169	Phosgene			TO-6	HPLC
				NIOSH 219	
170	Phosphine			NS	
171	Phosphoric Acid			NIOSH S333	COLOUR
172	Phosphoric Oxychloride			OSHA 2094	NVM
173	Phosphorus Pentachloride			NIOSH S257	COLOUR
174	Phthalic Anhydride			NIOSH S179	HPLC
175	Pimozide				
176	Platinum (H_2O soluble)			NIOSH S191	AAS
177	Polybutene-1-Sulphone				
178	Polychlorinated Biphenyls (PCBs)	MOE	GC/ECD	TO-4	GC/MS
				NIOSH 5503	GC/ECD
179	Polychloroprene				
180	Potassium Cyanide (as total salt)			NIOSH 7904	
181	Potassium Hydroxide			NIOSH 173	AAS
182	Potassium Nitrate			NS	
183	N-Propanol (N-Propyl Alcohol)	MOE	GC/FID	NIOSH 1401	GC/FID
184	Propionaldehyde			OSHA P129	NVM
185	Propionic Acid			OSHA 2168	NVM
186	Propionic Anhydride (expressed as Propionic Acid)			OSHA 2168	NVM

Appendix E (continued)

Nos.	Name of Contaminant	Cdn. Methodology Sampling	Cdn. Methodology Analytical	U.S. Methodology Sampling	U.S. Methodology Analytical
187	Propylene Dichloride			NIOSH 1013	GC/FID
188	Propylene Glycol Monomethy Ether Acetate			OSHA 2213	HPLC-UV
189	Propylene Oxide			NIOSH 1612	GC
190	Pyridine			NIOSH 1613	GC
191	Selenium			NIOSH 7300	ICP
192	Silane			NIOSH 7500	XRD
193	Silica-respirable (less than 10 micrometeres in diameter)			NIOSH 7500	ICP
194	Silver			NIOSH 7300	ICP
195	Sodium			NIOSH 7300	ICP
196	Sodium Chloride			NS	
197	Sodium Cyanide (as total salt)			NS	
198	Sodium Hydroxide			NIOSH 7401	A/B TITRA
199	Solvesso 100			NS	
200	Solvesso 150			NS	
201	Stannous Chloride (as tin)			NIOSH 7300	ICP
202	Styrene	MOE	GC/FID	TO-1 OSHA 9	GC/MS GC
203	Subtilisin (Detergent Enzyme)			OSHA 9220	NVM
204	Sulphation	MOE	COLOUR	NIOSH 268	IC
205	Sulphur Dioxide	EPS MOE	 FLUOR	EPA REF NIOSH 6004	FLUOR IC
206	Sulphuric acid			NIOSH 7903	
207	Suspended Particulate matter (particulate less than 44 microns in size)	EPS MOE	GRAV GRAV	EPA REF	
208	Talc (fibrous)			OSHA 9031	PH CONS MIC

Appendix E (continued)

Nos.	Name of Contaminant	Cdn. Methodology Sampling	Cdn. Methodology Analytical	U.S. Methodology Sampling	U.S. Methodology Analytical
209	Tellurium (except Hydrogen Telluride)			NIOSH S204	AAS
210	Tetrabutylurea			NS	
211	Tetrahydrofuran			NIOSH 1609	GC
212	Tetramethylthiuramdisulphide			NIOSH 5005	HPLC
213	Thiourea			OSHA T109	HPLC-UV
214	Tin			NIOSH 7300	ICP
215	Titanium			NIOSH 7300	ICP
216	Tolmetin Sodium			NS	
217	Toluene	MOE	GC/FID	TO-1	GC/MS
				TO-14	GC/MS
				NIOSH 1501	GC/ECD
218	Toluene Diisocyanate	MOE	GC/FID	NIOSH 2325	
219	Total Reduced Sulphur (TRS) as	MOE	COLOUR	EPA 16A	COLOUR
	equivalent H_2S	MOE	FLUOR		FLUOR
	(from Kraft Pump Mills)				
220	1,2,4-Trichlorobenzene			NIOSH 5517	GC/ECD
				TO-10	GC/ECD
221	1,1,1-Trichloroethane			TO-1	GC/MS
	(Methyl Chloroform)			TO-14	GC/MS
				NIOSH 1003	
222	Trichloroethylene	MOE	GC/ECD	TO-1	GC/MS
				TO-14	GC/MS
				NIOSH 3701	
223	Trifluorotrichloroethane			NIOSH 1006	
224	Trimethyl Amine			OSHA T127	DET TUBE
225	1-2-4-Trimethyl Benzene	MOE	GC/FID	OSHA 2505	NVM
226	Tripropyltin Methacrylate			NS	

Appendix E (continued)

Nos.	Name of Contaminant	Cdn. Methodology		U.S. Methodology	
		Sampling	Analytical	Sampling	Analytical
227	Vanadium	MOE	AAS	NIOSH 7300	ICP
228	Vinyl chloride	MOE	GC/FID	TO-2	GC/MS
				NIOSH 1007	GC/FID
229	Warfarin			NIOSH 5002	HPLC-UV
230	Whey Powder			NS	
231	Xylenes	MOE	GC/FID	TO-1	GC/MS
				TO-14	GC/MS
				OSHA 07	GC/FID
				NIOSH 1501	GC
232	Zinc	MOE	AAS	NIOSH 7300	AAS

KEY TO APPENDIX E SAMPLING & ANALYTICAL METHODS

AAS	Atomic Absorption Spectrometry
APHA	American Public Health Association
A/B TITRA	Acid/Base Titration
CHEM	Chemiluminesence
COLOUR	Colourimetry
DET TUBE	Detector Tube
ELECT MICRO	Electron Microscopy
EPA	Environmental Protection Agency, USA
EPS	Environmental Protection Service, Canada
FLUOR	Fluoresence
GC	Gas Chromatography
GC/ECD	Gas Chromatography/Electron Capture Detection
GC/FID	Gas Chromatography/Flame Ionization Detection
GC/FPD	Gas Chromatography/Flame Photometric Detection
GC/MS	Gas Chromatography/Mass Spectrometry
GC/PID	Gas Chromatography/Photoionization Detection
GRAV	Gravimetric
HPLC/UV	High Performance Liquid Chromatography/Ultra Violet
HRGC/HRMS	High Resolution Gas Chromatography/High Resolution Mass Spectrometry
IC	Ion Chromatography
ICP	Inductively Coupled Plasma
IR SPEC	Infrared Spectrometry
MOE	Ontario Ministry of the Environment
NDIR	Non-dispersive Infrared
NIOSH	National Institute for Occupational Safety and Health
NS	Not Specified
NVM	No Valid Method
OSHA	Occupational Safety and Health
PH CONS MIC	Phase Contrast Microscopy
SPEC - ???	Unknown
SPEC ION ELEC	Specific Ion Electrode
TLC	Thin Layer Chromatography
WHOLE	Whole Air Sample
XRD	X-Ray Diffraction

APPENDIX F

MOE Costs

Table F.1

MOE BUDGET ESTIMATE, 1988-89

	Budget 1988-89 (Millions)	Budget as % of total
1. Ministry Administration	$30.1	
Sub-total	$30.1	6.8
2. Environmental Services		
- Program Administration	$0.3	0.1
- Air Resources	$9.3	2.1
- Water Resources	$23.5	5.3
- Waste Management	$31.5	7.1
- Laboratory Services	$17.5	4.0
Sub-total	$82.1	18.6
3. Environmental Control		
- Program Administration	$11.2	2.5
- Env. Approvals & Land Use Planning	$9.4	2.1
- Investigations & Enforcement	$5.2	1.2
- Regional Offices (6)		
. Abatement/Technical Support	$35.4	8.0
- Other	$16.0	3.6
Sub-total	$77.2	17.4
4. Utility Planning & Operations	$253.1	57.2
Sub-total	$253.1	57.2
GRAND TOTAL	$442.5	100.0

*1 = this number obtained by subtracting 3 numbers above it from total

Source: MOE Budget Estimates, 1988-89

Note: All summaries are in 1988 Cdn. $.

Table F.2

COST TO AIR RESOURCES BRANCH OF APPLYING REGULATION 308

1. Phytotoxicology Section		
Assumes:		
75% of budget spent on Regulation 308	-	$733,000
2. Emission Technology & Regulation Development Section		
Assumes:		
0% of Vehicle Emissions budget spent on Regulation 308	-	$0
90% of Environmental Assessments budget spent on Regulation 308	-	$514,000
80% of Technology Development budget spent on Regulation 308	-	$192,000
80% of Source Measurement Unit budget spent on Regulation 308	-	$324,000
Other budget spent on Regulation 308	-	$165,000
3. Air Resources Special Projects		
Assumes:		
70% of (monitoring) budget spent on Regulation 308	-	$969,000
4. Air Quality and Meteorology Section		
Assumes:		
20% of Systems budget spent on Regulation 308	-	$41,000
20% of Regular budget spent on Regulation 308	-	$235,000
80% of Regions budget spent on Regulation 308	-	$160,000
80% of Instrumentation budget spent on Regulation 308	-	$294,000
5. Administration & Director's Office		
Assumes:		
33% of Branch Admin. budget spent on Regulation 308	-	$292,000
TOTAL		$3,919,000

Source: Mr. Chester Duncan, Manager
Emission Technology & Regulation Development Section

Note: All sums are in 1988 Cdn. $.

Table F.3

COST TO ENVIRONMENTAL APPROVALS & LAND USE PLANNING BRANCH OF APPLYING REGULATION 308

Assumes:

33.3% of budget spent on Regulation 308	-	$3,133,333
33.3% associated administration spent on Regulation 308	-	$667,714
TOTAL	-	$3,801,048

Source: Mr. Tom Armstrong, Manager
Approvals Section
Environmental Approvals and Land Use Planning Branch

Note: All sums are in 1988 Cdn. $.

Table F.4

COST TO INVESTIGATIONS & ENFORCEMENT BRANCH OF APPLYING REGULATION 308

Assumes:

62 % of Branch budget spent on Regulation 308	-	$3,200,000
62 % of associated administration budget spent on Regulation 308	-	$681,921
TOTAL	-	$3,881,921

Source: Mr. Ron Clark, Assistant Director
Investigations & Enforcement Branch

Note: All sums are in 1988 Cdn. $.

Table F.5

COST TO REGIONS OF APPLYING REGULATION 308

Region	Location	Total Budget 1988-89 (Million)	Of which: a. Abatement Total	on 308	Percent	b. Technical Support Total	on 308	Percent	c. Other Total	on 308
Central	Toronto	$8.25	$5.47	$0.82	15	$2.35	$0.58	25	$0.42	$0.00
NE	Sudbury	$5.25		$0.52			$0.37			$0.00
NW	T. Bay	$4.66		$0.46			$0.33			$0.00
SE	Kingston	$5.75		$0.57			$0.40			$0.00
SW	London	$6.50		$0.65			$0.45			$0.00
W Cent.	Hamilton	$4.99		$0.50			$0.35			$0.00
TOTAL		$35.40		$3.52			$2.47			$0.00

Note: Only the Central Region has been contacted.
Calculations of expenditures on Reg 308 for other regions have been made based on the assumption that the percentage of budgets spent on Regulation 308 is the same

Source: Mr. George Mierzynski, Director
Toronto Regional Office

Note: All sums are in 1988 Cdn. $.

APPENDIX G

Abbreviations Used in Tables

ABBREVIATIONS USED IN TABLES

neg	negligible
FID	flame ionization detector
PID	photoionization detector
ECD	electron capture detector
NPD	nitrogen/phosphorus detector
FPD	flame photometric detector
HECD	hall electrolytic conductivity detector
TEA	thermal energy analyzer
n/a	not applicable
neg	negligible
VOCs	volatile organic compounds
PM	particulate matter
SO_2	sulfur dioxide
NO_x	nitrogen oxides
CO	carbon monoxide
Cl_2	chlorine
ClO_2	chlorine dioxide
ESP	electrostatic precipitator
F	fluoride
H_2S	hydrogen sulfide
HC	hydrocarbons
NH_3	ammonia
S	sulphur
PVC	polyvinyl chloride
CH_4	methane
ROG	reactive organic gases
HCl	hydrochloric acid
Pb	lead
Hg	mercury
Cd	cadmium
Cr	chromium
PCDD	polychlorinated dibenzo dioxins
PCDF	polychlorinated dibenzo furans
PCB	polychlorinated biphenyl
PAH	polycyclic aromatic hydrocarbons
CDD	chlorinated dibenzo dioxins
CDF	chlorinated dibenzo furans